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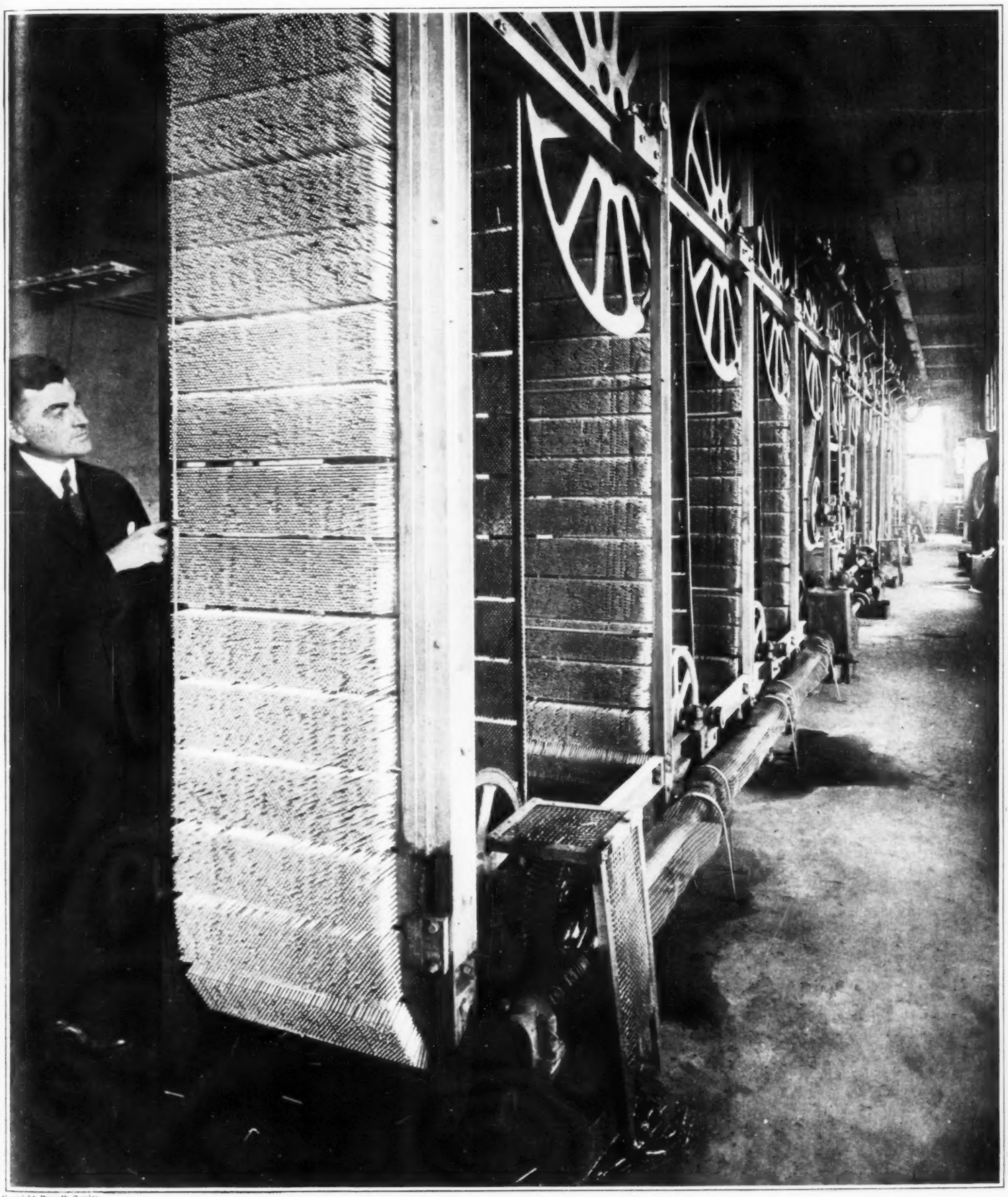

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General view of a machine that dips several millions of matches a day

HOW MATCHES ARE MADE [See page 56]

Life and the Structure of Molecules*

A Discussion of the Biological Properties Involved

By Amé Pictet

Among all the problems which nature presents to the mind of man the most absorbing is undoubtedly that of life itself. Its solution must be sought in all the physical and natural sciences taken as a whole, and demands the employment of the most powerful means of investigation at our disposal. However, it is upon the science of biochemistry that the principal part of the task devolves. It cannot be doubted, in fact, that if life itself be not a chemical process, at any rate the phenomena of which it is the cause are chemical in character.

But biochemistry is itself based upon pure organic chemistry. A fundamental condition, in fact, of the ability to interpret any phenomenon correctly is an exact knowledge of the medium within which it develops, and in the present case it is to organic chemistry that we must look to establish the nature of the materials of which living creatures are composed. The primary object of organic chemistry is to separate, to purify, to describe, and to analyze the innumerable compounds which we derive from animals and from plants. But it does not stop here. It has the further object of endeavoring to comprehend what is termed the *constitution* of these bodies, *i. e.*, the intimate architecture of their molecules, the exact positions occupied by each of their atoms and the relations between these atoms. In the great majority of cases this task has been successfully accomplished, and thus there has been performed a tremendous piece of work, which, in the phrase of one of our most eminent contemporary physical-chemists, Nernst, represents the most remarkable achievement thus far of the human intellect.

Let me hasten to add that the enormous sum of labor involved in these researches has not been inspired solely by the speculative interest which attaches to all new knowledge. The chemists who have thus dissected all the organic molecules, who have drawn up the plans of these minute edifices, have been impelled by two other purposes of a more immediate nature.

In the first place by the attractiveness of *synthesis*. We have learned that the artificial reproduction of natural compounds has no chance of succeeding unless the constitution of the latter is known in its minutest detail. Whenever anyone has attempted to proceed differently, to put the cart before the horse, as we may say, by operating empirically, success has been lacking; the most recent example of this fact is afforded by the fruitless endeavors to manufacture rubber artificially.

Chemists have devoted their attention, in the second place, to questions of constitution, since they have not been slow to recognize the fundamental fact that all the properties of organic compounds, whether of physical, of chemical or of physiological nature, are closely related to the problem of constitution. It is neither the quantity nor the nature of the materials employed in constructing a building which make of it a church, a theatre or a railway station; it is merely the arrangement of the materials; in the same way it is neither the kind nor the number of the atoms in its molecules which make of an organic compound a dye, an antiseptic or a perfume. It is solely the manner in which these atoms are grouped with respect to each other. Hence to know this mode of grouping is to possess the means of preparing with certainty, and at will, any given new compound whose properties have been determined in advance.

A vast mass of highly interesting relations have thus been established between the constitution of bodies and certain properties, such as color, flavor, density, tinctorial power, rotatory power, pharmacological power, etc. But it is necessary that every domain should be explored ,and there is one in particular, namely, that of biological properties, which there has been as yet no attempt to connect with the structure of molecules.

It is this subject which I wish to bring before you. I will begin by limiting it by means of the three questions which follow:

1. Does there exist any relation between the chemical constitution of the body and the role it plays within the living organism?

2. Does there exist any condition of molecular structure which renders a substance useful, injurious or neutral, as the case may be, with respect to the maintenance of life, which makes of it, in other words, a food or a poison?

3. Does there exist any similar condition whereby the matter of a living cell may be distinguished from that of the same cell when dead; in other words, does death result from a change in the architecture of the molecules?

Before attempting to reply to these questions it appears to me desirable to define the special point of the theory of the constitution of molecules upon which my answers will bear. But I shall confine myself to strictly necessary statements. Further than this I need only recall to your minds the essential principle of organic classification.

We have learned by fifty years of patient research that the organic compounds thus far known, approximately 150,000 in number, belong to two types only so far as concerns their molecular structure, in spite of their enormous variety.

In the first type the atoms of which they are composed, namely those of carbon, oxygen, or nitrogen, in the process of satisfying their chemical affinities, either wholly or in part, form chains which vary in length and are practically rectilinear. Thus the central portion of the molecule forms a sort of vertebral column upon which other atomic groups are grafted later on.

In the second type these same atoms are united under the influence of the same attractive forcse, but they form chains whose two ends meet. Thus the skeleton of the molecule ceases to be a mere string of atoms and becomes a ring. And around the periphery of this ring similar groups may cluster, just as the flesh of a fruit surrounds its kernel.

Thus we have a distinction between *open chain compounds* and *cyclic compounds*. Today we consider this distinction to be the fundamental basis of organic classification. It corresponds, for example, to the division of the animal kingdom into vertebrates and invertebrates, and is not without a certain analogy to that division since it is likewise based upon the conformation of the skeleton and upon the system of symmetry of the organism. These two great classes of organic compounds are separated theoretically by a wide chasm. But this chasm can be bridged. In many cases it is possible to act upon the molecules of bodies by means of appropriate reactions in such a manner as to cause the ends of an open chain to unite (this process is called *cyclization*) or, on the contrary, to break a closed chain (an operation which may be called *cyclolysis*). Thus it is possible to pass experimentally from one type to the other.

To be sure, this passage is incomparably easier in one direction than in the other. One of the characteristics of closed chains is their stability, and it always requires a considerable chemical effort to disunite the links. Cyclization, on the other hand, is far more readily produced; however, it demands a certain increase of energy necessitated by the bending of the rectilinear chain and the welding together of its two terminal atoms. The question arises as to what forms of energy are capable of performing this work.

In the first place there is heat. Berthelot first demonstrated this by causing a series of open chain substances to pass through tubes whose temperature was raised to a red heat. He thus obtained numerous cyclic compounds and, in particular, the majority of those which are mingled together to form coal tar, that by-product of the manufacture of gas from which modern chemistry is able to extract so many valuable derivatives. Berthelot even estalished upon the basis of the experiments his famous theory of the formation of coal tar. According to this theory the coal is entirely decomposed in the course of its distillation into very simple linear skeleton gaseous products, which products are suddenly cyclisized by contact with the hot walls of the retorts. We shall consider the value of this explanation further on.

But cyclic compounds are not found in coal tar alone. We encounter them in substances which have never been subjected to severe heat, in petroleum, for example. They are particularly abundant in living organisms, and especially in plants. In this case the agent which has produced the cyclization is not calorific energy; we must seek further for the cause, and shall find it directly.

But allow me first to make a preliminary remark. According to what I have just said to you it would seem that the properties of an organic compound must vary absolutely with respect to whether the body belongs to the open chain class or to the class of cyclic substances. But observation shows that this is not true. On the contrary both classes contain alcohols, acids and bases, flavorous or ordorous substances as well as those which have neither flavor nor odor, and both poisonous substances and those which are harmless. The chemical industry derives its perfumes and its explosives, and the art of medicine its drugs, indifferently from one class or the other. Color alone appears to bear some relation to cyclic structure, but this is true only to a limited degree.

We are forced to conclude, therefore, that these properties are but little influnced, or not at all, by the conformation of the skeleton of the molecule; they depend essentially upon the nature of the peripheral groups which surround the skeleton, and which may be the same in both cases. We have here a fact which is apparently very strange; it is difficult to comprehend why a characteristic so essential from a theoretic point of view as the structure of the skeleton should have no effect upon one of the fundamental properties of the substance.

But it is just at this point that my personal observations enter into the question, and I may state that this anomaly, which would be quite inexplicable, in reality does not exist. I believe I am justified in affirming, on the contrary, that there is an entire ensemble of the fundamental properties of matter which is governed respectively by the cyclic or linear nature of the molecular skeleton. These properties are those which come into play in all the manifestations of *life*. It is this which I will attempt to demonstrate.

If we would study vital phenomena in their simplest manifestations we must observe them not in the animal but in the plant. Let us consider, therefore, the green plant, the organism upon which devolves the task of transforming the mineral substances of its environment into organic matter, and finally, into living matter which the animal needs only to break down and to burn later in order to utilize the energy which it contains in the potential state.

What, then, is the mechanism of this marvelous synthesis? As yet we do but know it very imperfectly. But we know the intermediate products through which it passes. These are the formic and glycolic aldehydes, the sugars and starches, the numerous vegetable acids, asparagin, glycerine, the fatty matters, the lecithins; these substances exist in all plants; we detect their presence in every living cell, together with the proteins which constitute the essential elements of the protoplasm. Apparently, therefore, they may be regarded as the aliments of the cell.

But when we consider the constitution of these bodies we are struck by the fact that their molecules contain only open chains of atoms. None of them exhibit the cyclic structure. Thus we perceive a primary relation between the constitution of the molecule and the rôle of the vegetable substances. All of these which may be legitimately considered as the direct and successive product of assimilation, all these which contribute to the building and the maintenance of the living protoplasm, belong to the first class of organic compounds. But these substances are far from being the only ones which the vegetable kingdom yields. Besides these the plant produces an infinite variety of others which human industry has at all times sought to obtain, not to use as foods but in order to derive a profit from some other of their properties. This is the case, for example, in the great family of the essential oils, the turpentines and the camphors, many representatives of which constitute our most highly appreciated perfumes or condiments. Furthermore, there is a long series of vegetable pigments and dyes, from chlorophyll down to that interesting group of the anthocyanins or flower pigments, whose systematic study has been recently undertaken by our former colleague, Willstaetter. Then there are the different resins, the rubbers, the tannins, the glucosides and the various bitter or astringent principles. Finally, we have all those numerous nitrogens and basic compounds to which the collective name of alkaloids is given, and which have become our most valuable medicaments for the reason that most of them are endowed with a remarkable physiological action upon the animal organism.

Is the rôle which these substances play in the plant the same as that of the compounds in the first category? It was formerly believed so. Even today many plant physiologists hold this view, and consider these materials to be reserves of nutrition which the plant will

*An address delivered before the Helvetian Society of Natural Sciences. Translated from the Geneva Archives of Phys. and Nat. Sc. for the Scientific American Supplement.

utilize at the proper moment for the maintenance of its tissues.

I do not agree with those authorities, and my reasons are as follows: These substances do not appear to me to be indispensable to the development of the plant as are those in the first category, since many plants entirely lack them. We do not find them stored in the seeds or the roots as are the others. We never encounter them in the living cell, from which they seem to be excluded, but only in special receptacles or tissues in which they are localized and seem to be set aside from the great pathway of proteinogenesis. We do not see them disappear during the course of the life of the plant; on the contrary, they accumulate. It is certain, therefore, that they are not intermediary products in the building of living protoplasms. We must seek elsewhere than in a process of assimilation for the genesis of these compounds, which, without nutritive value for the plant, are yet engendered by it often in very considerable quantities. What, therefore, is their origin and their significance?

Some years ago I formulated a hypothesis upon this subject with special reference to the alkaloids. This hypothesis having been received with considerable favor I now extend it to all compounds of the same order. It is my opinion that, far from being products of assimilation, they are products of denutrition. They represent the waste matter of plant metabolism. They correspond to the animal products, urea, uric acid, glycocoll, the pigments of the bile, etc. It is not conceivable in fact that the biologic synthesis of the proteins should be performed with a theoretic yield containing no accessory products, that is residues no longer usable, any more than is any synthesis whose operation takes place *in vitro*. Furthermore, in the plant as well as in the animal similar waste matter, either nitrogenous or non-nitrogenous, must be produced necessarily by the wear of the tissues and all the phenomena of assimilation and combustion. All these products are not only useless but actually injurious to the maintenance of life. They are poisons of which the organism, whether plant or animal, must rid itself at any price under penalty of auto-intoxication. The animal does this by excreting such products outside itself, but the plant, which lacks excretory organs, can do this but imperfectly. It must, therefore, resign itself to living with them and confine itself to rendering them inoffensive by keeping them outside the vital circuit, and preventing them from penetrating anew into the living cell whence they came and there exerting their harmful action upon the protoplasm. And we see that the plant is successful in this since the compounds in question are never found inside the living cell. Its wall, therefore, forms a barrier between the useful substances and the injurious ones; it is permeable by the first and impermeable by the second. Is it possible to form an idea of the mechanism which controls this sifting process?

No physical characteristic (such as solubility, ionization, the colloidal or crystalline state) distinguishes one of these two categories of substances from the other. Neither does there exist any difference of chemical composition between them; they are formed of the same elements, which are, indeed, those of the protoplasm itself. In my opinion, therefore, their opposite behavior can be explained only by a difference of molecular structure. Let us examine, therefore, the facts that are known regarding their constitution.

Researches upon this subject have led to the remarkable conclusion, all of whose consequences are not as yet revealed, that all these products are cyclic compounds. The atoms of carbon in the turpentines, the camphors, and the tannins; the atoms of carbon and of oxygen in the anthocyanins; and the atoms of carbon and nitrogen in chlorophyll and in all the alkaloids are uniformly united in closed chains. As we have seen the reverse is true of the nutritive substances of the cell. I behold, therefore, in this different arrangement of atoms the reason why the molecules of one kind are able to penetrate the living cell, while those of the other kind are excluded. An iron wire will pass through a very narrow opening if introduced by one end, while it will not pass through if it be rolled into a circle. In the same way the intermolecular apertures of the cellular walls will allow the flexible chaplets of the open chains to pass, while they will oppose the entry of the massive rigid rings which form the cyclic molecule.

But the dejecta of metabolism are originally open chain bodies like the substances from which they proceed. Hence, it is only by sudden jerk, so to speak, that they require the cyclic structure which renders them inoffensive. There is a reaction of the living plant against the toxic principles which it produces, and this reaction consists in a modification of the intimate structure of these principles; the plant defends itself against the poisons it produces by causing their cyclization. It is evident, therefore, that there are in the plant organism two processes of parallel syntheses in one of which the atoms are united by simple juxtaposition to form long open chains which finally constitute the complex molecules of the proteins, while the other, carrying on a regular sewerage system, cleanses the organism of all the detritus left behind by the first synthesis, by winding up into rings all those fragments which are no longer capable of aiding in the construction of the edifice, or which become detached when the edifice crumbles into ruins.

This hypothesis having been formulated, it remained to verify it by experiment and to show how cyclization operates in the plant. It is this which I have endeavored to do by means of my investigations concerning the alkaloids. Starting with the idea that in organic synthesis the best method of attaining our object is to imitate nature, I have always endeavored in my attempts at the artificial reproduction of vegetable alkaloids to operate under conditions resembling as closely as possible those which occur in the living plant. It was this idea which presided over the recent researches conducted in my laboratory by Messrs. Gams, Spengler, Kay and Malinovski and by Mlle. Finkelstein—researches which led to the synthesis of berberin and of several of the alkaloids of opium.

As points of departure for our operations we always chose on the one hand substances which are known to be formed in plants by the disintegration of the proteins, and on the other hand compounds such as formic aldehyde, which are primarily derived from the carbon dioxide of the air. By combining the one kind with the other kind we succeeded in obtaining cyclic alkaloids, and these were found to be identical with those produced in the tissues of plants.

I even succeeded, in collaboration with M. Chou, in obtaining alkaloids directly by hydrolyzing *in vitro* the albumens themselves in the presence of formic aldehyde.

It seems to be clearly proved, therefore, that the alkaloids are formed in the plant by the cyclization of the products of decomposition of the proteins; and by analogy we are justified in attributing the same origin to all similar compounds.

To sum the matter up, a complete parallelism is to be found between the two great divisions of organic compounds, based on the structure of their molecular skeleton and upon the rôle which they play in the organism of the plant. Only the open chain compounds are capable of sustaining the life of this organism, while the closed chain compounds, which we find in abundance in certain plants, are merely dejecta without nutritive value and made inoffensive by the mere fact of their cyclization. The ideal plant, in fact, would contain none of these compounds.

But a serious objection to this conclusion immediately presents itself. Every chemist and every botanist will thrust it upon me, saying: In the enumeration of the substances in the plant which do not contribute to the formation of its protoplasm you have omitted the most important of all, the *cellulose*, that substance which is so essential from the morphological point of view, and which throughout the whole extent of the kingdom of plants forms the wall of the cells and of the vessels, exerting a fundamental rôle in the mechanical protection of the protoplasm by providing the necessary envelope enabling it to organize itself into more or less rigid and resistant tissues.

It seems indispensable, my critic will continue, that the substance upon which this function devolves should possess sufficient chemical stability to resist the multiple actions which take place in the plant. It is necessary that it should remain outside the general metabolism. If the ideas which you have developed are correct this indifference must result from its molecular structure, and cellulose must possess the cyclic structure like all the other compounds which the plant excludes from the vital circuit. But all chemical treatises place cellulose beside starch among the open chain compounds, and this fact alone is sufficient to demolish the framework of your theory. I must acknowledge that it would be impossible to reply to this objection if it rested upon a solid basis, *i. e.*, upon an exact knowledge of the constitution of cellulose. But this constitution has thus far never been determined, and the analogy with starch is not sufficient to establish it. I believe, on the contrary, that cellulose must occupy a place remote from that of starch as regards its classification, and that it should be placed among the compounds possessing the cyclic structure. A series of experiments conducted by me with the assistance of MM. Ramseyer and Bouvier enable me to offer you some proof of the theory which I have just advanced. These experiments were instigated by the following considerations.

The chemical phenomena which cause the decomposition of the plant after its death differ according to the conditions in which they occur. If the plant is left to itself in the open air, its nitrogenous matters first undergo a rapid putrefaction, with the formation of ammonia, which is absorbed by the soil, and of carbon dioxide which returns to the atmosphere. The non-nitrogenous substances, and cellulose in particular, resist longer, but finally they also disappear by means of a slow combustion, whose agent, either direct or indirect, is the oxygen of the air.

If the dead plant is more or less covered with the soil instead of remaining in the open air, this action of the oxygen is retarded, and there is a formation of humic matters, substances which are still very ill-defined as regards the chemical point of view, but of which it is known that they are the products of the incomplete oxidation of the cellulose, and that they exhibit the characteristics of phenols, *i. e.*, of cyclic compounds.

Finally, if these same vegetable matters are entirely removed from the action of the air, either by immersion in water or by being covered with large masses of earth, as is the case where vast geologic dislocations have occurred, they still undergo a slow transformation. But this change can no longer be considered an oxidation; it is a decomposition of a special sort of whose laws and whose agents we are still ignorant, but with whose ultimate products we are well acquainted—these products are our fossil combustibles of various periods, including lignite, soft coal and anthracite. It cannot be doubted that it is the cellulose which provides the essential matter of these *carbons of the earth*. In this transformation the cellulose loses a part of its oxygen and of its hydrogen and consequently contains a higher percentage of carbon. But since this decomposition takes place at a low temperature it involves only the periphery of the molecule; the carbonized skeleton is not affected. We are forced to believe, therefore, that the structure of this skeleton is identical in coal and in cellulose, so that by determining it in the former, we discover its nature in the latter.

Unfortunately, although coal has been used as a combustible for a couple of centuries, and though for a hundred years there have been extracted from it by distillation three products of such vast industrial importance as illuminating gas, coal tar and coke, we are still almost entirely ignorant, strange to say, of its chemical nature. Is it possible to deduce this nature from the study of the products of this distillation? We know, as I but just now stated, that coal tar is formed exclusively of cyclic compounds. The same thing is true of coke; the fact that it furnishes through oxidation aromatic acids assures us that the atoms of carbon which compose it are united in closed chains. Does this mean that we may attribute the same structure to the materials whence they proceed? Such a deduction would be absolutely unjustified, for these materials have been subjected during the distillation of the coal to temperatures of from 800° C. to 1,000° C., and we know by the experiments of Berthelot that these temperatures are amply sufficient to cause the cyclization of all the open chains.

To avoid this objection it would be necessary to eliminate the idea of the cyclization produced by heat during the decomposition of the oil. It is this which I endeavored to accomplish with the aid of my two admirable collaborators by performing the distillation of the coal in a vacuum, by which means we were able to prevent the temperature from rising above 450° C. We obtained a special form of coal tar and a new kind of coke. But the study of this *vacuum coal tar* and this *vacuum coke* revealed the fact that both of them are exclusively cyclic in nature, just as are ordinary coal tar and ordinary coke. We conclude, therefore, that the cyclic compounds pre-exist in the coal and certainly form the major portion of it. It is our opinion, moreover, that these experimental results involve the three following consequences:

1. Berthelot's theory with regard to the formation of coal tar can no longer be regarded as giving a precise interpretation of the facts. We can no longer consider all the derivatives of coal tar, which the chemical industry has so brilliantly utilized, to be products of pyrogenation as had been believed. It is not to the heat of the gas retorts that they are in debt for their famous *aromatic nucleus* which is so rich in valuable properties. This nucleus already existed, although in a more hydrogenated state, in the plants of the carboniferous epoch. The whole science of aromatic chemistry is thus shown to depend upon the chemistry of the plant.

2. The vacuum coal tar is, in reality, nothing other than *petroleum;* it possesses the odor, the density, the

(Continued on page 59)

Photos copyright, Kadel & Herbert, N. Y.

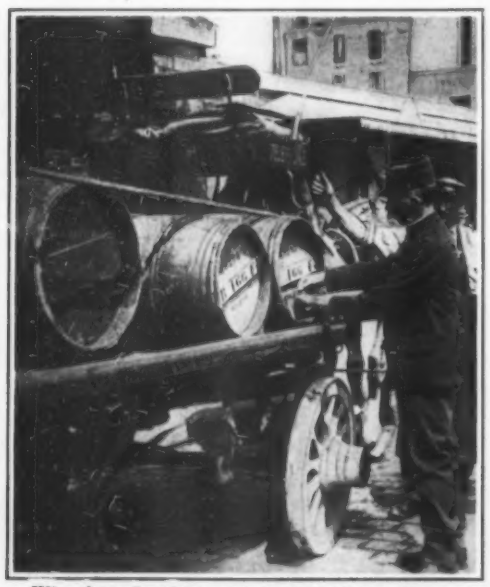
Every load of hay going from Switzerland to Germany was sounded for contraband goods

An innocent looking roll of cloth used for concealing rubber

Contraband Trade Between Switzerland and Germany

ALTHOUGH Switzerland ranked as a neutral during the great world-war, and probably did maintain her standing quite creditably considering the delicate circumstances of her position, still curious conditions prevailed, as to strictly enforce her neutrality would be to offend Germany, which would have been dangerous on account of her position; and, moreover, people of every nationality could pass between the two countries with little difficulty. As a result there was quite an active commerce between the two countries, much of which was quite at variance with the principles of neutrality. Smuggling was rife all along the border, and notwithstanding the efforts of the Swiss Government, Germany obtained considerable quantities of needed materials, and the thrifty Swiss enjoyed exceptional profits, which was enough to induce them to engage in this underground commerce, whatever their sympathies or affiliations may have been. Of course, German agents were very active in this traffic, and probably the greater part of the materials scrreptitiously transferred across the borders was the result of their efforts; but most everyone took a part in it as opportunity offered, and it was a common thing for women and children who lived near German territory to slip across with a small parcel of necessaries that could be readily disposed of at a good profit, thus adding somewhat to their slender incomes and helping tide over the period of high cost of living.

The accompanying illustrations show some of the methods resorted to by the smugglers, and also the strict watch that was maintained by the officials, and these explain themselves quite clearly. It is hardly necessary to say that this was the route by which much German propaganda found its way to other countries.



Wine barrels often contained alcohol and other needed liquids

Spontaneous Explosion of the Charcoal in Liquid-Oxygen Containers

THE use of liquid air and liquid oxygen in the chemical and mining industries, in the latter case as blasting agent, has much spread on the Continent during the war. The liquid air is generally transported in double-walled vessels (vacuum-jacket vessels) which

Books with secret compartments were much used by smugglers

are made of metal rather than of glass, and the jacket space is usually charged with some superior charcoal in order to maintain the vacuum during the gradual emptying of the vessel. Several recent cases of explosion of such vessels have been investigated by Professor Lothar Wöhler (*Chemiker Zeitung* of October 5, 1918). He found that the explosions occurred because the inner metal of the vessel had been broken, and the liquid oxygen had been absorbed by the charcoal at an explosive rate. All the vessels in question had been supplied by one Austrian firm, and Wöhler failed to produce explosions by breaking, with the aid of a tool, either the walls of vessels of the Sprengluft-Gesselschaft, of Charlottenburg, which are charged with a charcoal of the highest absorptive power, or the walls of other vessels, charged with ordinary charcoal. The analyses demonstrated that the charcoal of the faulty vessels was rich in both zinc and iron. When iron chloride was added to ordinary charcoal, this did not turn explosive. The superior charcoal of the company named became explosive, however, when containing 3.5 per cent. of iron; when containing only 3 per cent. or 2 per cent. of iron, the access of oxygen gave rise to a violent combination, but not to an explosion, and smaller percentages of iron had no deleterious effect. It was thus clear that an explosion would only occur when the charcoal was not only impure, but also very highly absorptive. The presence of ammonia in the charcoal made no difference in the observations. Addition to the charcoal of substances like colophony, naphthalene or powdered pyrite, substances which would favor electric excitation by friction, did not render a safe charcoal explosive either. The iron was not present as metal, but probably as iron oxide; addition of powdered iron oxide did not do any harm either, while, on the other hand, extraction of a contaminated charcoal with hydrochloric acid removed the dangerous constituent. It seems thus certain that explosions are only to be feared when a very highly absorptive charcoal contains a certain amount of iron and possibly also of other impurities. Finely divided phosphorus, *e. g.*, is dangerous; but that was to be expected, and contamination of the charcoal with phosphorus is hardly likely. The iron oxide seems to act catalytically as oxygen carrier, and a small quantity of charcoal, 0.1 gramme, proved sufficient to cause an explosion, provided the conditions above stated were fulfilled. There have also occurred a few cases of explosions of blasting cartridges containing soot or sawdust and liquid oxygen. These accidents are of a different nature; they occur during the tamping of the bore holes when the oxygen prematurely gains access to the combustible which the mechanical friction has heated.—*Engineering.*

Measuring Fluctuating Temperatures

ACCORDING to *Elektrotechnic und Maschinebau*, special apparatus has recently been contrived to measure rapidly fluctuating temperatures such as an ordinary thermometer is too sluggish to record. At the point of measurement, wires of platino-iridium, 0.02 mm. diameter, are inserted and are connected to a galvanometer. The deflection varies with the resistance of the wires, and it is stated that variations in temperature with a frequency of ten per second may be noted. It is anticipated that the apparatus will be specially useful for studying cylical variations in temperature in the cylinders of steam engines and combustion engines.

This is the body of a carriage having a hollow seat and floor

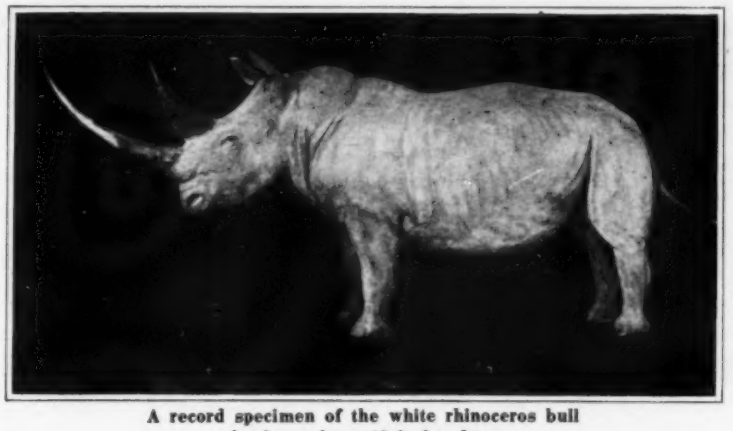
The Finest Specimens of White Rhinoceros in Africa

THE American Museum of Natural History, New York, has placed on exhibition on the second floor a unique series of skulls and horns of the rare white, or square-lipped rhinoceros. At the beginning of the last century the white rhinoceros was common in South Africa, but the rapid progress of civilization has brought about its practical extinction, until only a few are left on a preserve. In 1900, Major Gibbons quite unexpectedly discovered some of the beasts far northward on the left bank of the Nile, in the Lado territory between the Belgian Congo and the Sudan. During his famous African trip, Colonel Roosevelt obtained some, two of which he presented to the American Museum. Messrs. J. Pierpont Morgan and John H. Prentice have also made gifts of white rhinoceros material to the Museum.

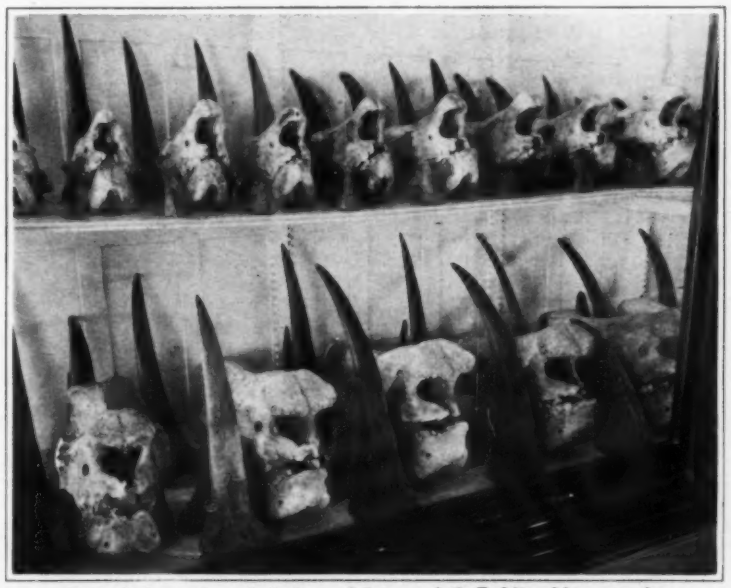
It often happens that hunters make terrific inroads on even such rare game, and while the Belgian Government forbade sportsmen to shoot more than a single specimen, the natives were permitted to slaughter them indiscriminately for food. The Congo Expedition, maintained in Africa for six years by the American Museum, had the opportunity of gathering bones and skins from the natives' spoils, and by this means the great natural history museum now owns the largest and most complete collection in existence of skulls and skeletons of the white rhinoceros, including an uninterrupted series from the unborn young to the old record bull. The unique set of horns shows not only the gradual development from the single horn of a new-born calf, weighing only an ounce, to the heaviest pair, weighing thirty-eight pounds, but also a great variety in form, which ranges from the perfectly straight to the nearly semi-circular.

In the campaign waged by the Congo Expedition, this collection formed the most convincing proof of the necessity of securing a more saisfactory protection for these animals from the reckless slaughter by native hunters.

Great progress has been made by the American Museum in the preparation of a habitat group, for which all the necessary materials have been collected. A young specimen and the record bull, with a horn forty-two inches long, have been completed, and the largest female, with a horn over thirty-six inches long, is almost ready. These are the finest specimens of the white rhinoceros ever gathered, and the group will be a worthy addition to the interesting habitat groups which draw so many visitors to the exhibition halls of the American Museum of Natural History.



A record specimen of the white rhinoceros bull having a horn 42 inches long



Part of the series of skulls and horns of the white rhinoceros in the American Museum of Natural History at New York

The Sign of the Zinc Pole in a Battery

THE vexed question has once more cropped up whether the zinc terminal of a primary battery should be called the negative pole—which is the actual common practice—or the positive pole. The problem rather presents itself under a different aspect, as we shall see, but it comes down to this question. Scientists have changed their standpoint several times since the days of Volta. The introduction of the secondary battery caused renewed difficulties to the student already bewildered by the disagreement of investigators. The plate, which was the anode or positive pole during the charging period of an accumulator, became the negative electrode during the discharge, which is the essential period for an accumulator. Of late there has been fairly general agreement as to the sign of the zinc pole or of the terminal on the electrode which corresponds to the zinc of a primary battery, and it does not seem advisable to disturb that agreement by renewed discussions as has recently been done chiefly by American electrochemists like G. N. Lewis. The controversy is as old almost as the fundamental experiments of Galvani and of Volta of 1786. Galvani suspended frog legs by a copper wire from an iron railing and observed that the legs contracted when they happened to come in contact with the iron; he was studying the influence of electricity on nerves, and he ascribed the phenomenon to animal electricity. Volta opposed this view, and maintained that the essential thing was the direct or indirect contact between the iron and the copper. Both views found supporters at the time; later, Volta's theory conquered. At present few scientists probably would care to express their opinions on animal electricity and on contact electricity in a few words. In Volta's pile the zinc was called the positive plate and the copper the negative plate. The pile soon made room for the battery of cells, however, and in cells the chemical forces between the metal and electrolyte rather than the contact forces between the metals are considered the source of the energy. Berzelius already designated the more oxidisable of two metals as electropositive with respect to the other. But in the Daniell cell the zinc pole is marked negative, and the copper pole positive. That is because we have to distinguish between the current in the cell, which flows from the zinc through the electrolyte to the copper, and the current in the outer circuit which flows from the copper to the zinc. Now the external circuit gives us the current we want for doing work, and as this explanation brings the dynamo and the primary battery into line as sources of electric energy, it finds favor with engineers and physicists. It is less acceptable to the electro-chemist, however, who has to calculate the electrolytes and who, in corrosion problems, is more interested in the phenomena of the internal circuit than in those of the external circuit. The rule just given for fixing the polarity is, moreover, based on an argument which really does not help us much, that is, that the current flows from a place of higher potential to one of lower potential. On that rule the same zinc plate has the higher potential of the two metals within the cell, and the lower without the cell. The real difficulty is about the single potentials. Some scientists said that a zinc electrode assumed a negative potential in a solution of its sulphate, others preferred to call it positive. According to Nernst's theory of solution pressure, zinc sends positive ions into its sulphate and thereby becomes negative; others called it positive for that reason, and objected that, since zinc has more free energy than copper it must be considered positive. In a paper on "The Sign of the Zinc Electrode" (Journal of Physical Chemistry, May, 1918), Professor Wilder D. Bancroft tries to show that the difficulty is not real, and that it vanishes, when we say that the chemical potential of the zinc in the cell is greater than the chemical potential of the copper, but its electrical potential is less. With an electrode which forms anions, he proceeds, the two potentials have the same sign, with electrodes which form kations they have opposite signs. His arguments, we are afraid, do not clear up the difficulty, though the distinction between chemical and electric potential may concisely have been stated by Gibbs, as he says.—*Engineering.*

War Substitutes for Soap in Germany

As is well known, the continued provision of oils, fats and their associated products, soap and glycerin, has occasioned our enemies the greatest concern and almost every known method of augmenting the supply from internal sources has been resorted to, such as the oxidation of lignite-tar oils and the treatment of ozonides. Various substitutes for soap have been devised, made of clay, kaolin, chalk, etc., mixed with silicate of soda, glue, and an antiseptic such as boric or salicylic acid, with sufficient saponin (usually quillaya bark) to produce a lather. The Kriegs Anschuss placed on the market a soap consisting of fatty acids and saponified resins with clay and sodium carbonate at a maximum price of 20 pfennigs for 50 grams per head per month. This is supplied to hospitals, doctors, and certain groups of workmen. Such industries as textiles, leather, bleaching and dyeing have been seriously incommoded, and recovery processes have been rigorously insisted upon. The deficiency of fats has of course affected the production of glycerin. Its therapeutic employment has been practically forbidden, and its recovery whenever possible is compulsory. A solution of calcium chloride is employed as a substitute in certain industries. Ethylene glycol has replaced it as a medicament, and in the preparation of films, in printing, and in lithography. Various vegetable decoctions stabilized by antiseptics are also used. Concentrated solutions of lactate of soda and of potash, under the names of "perglycerin" and "perka-glycerin," have been introduced into pharmacy.—*Nature.*

Japanese Black Mint

THE Japanese black mint plant, from which menthol is obtained, is cultivated in two widely different climates. Some 92 per cent of the total production is grown in the northern island (Hokkaido), which has an average yearly rainfall of about 38 inches and mean summer and winter temperaturse of 60° F. and 22° F. respectively. The remaining 8 per cent is grown on the main island (Okayama and Hiroshima), where the rainfall is 42.5 inches and the average temperatures 75° F. and 38° F.

The mint requires a light, well-drained soil. The roots are planted (in Hiroshima and Okayama), at the end of November and the beginning of December. The plant attains its full growth during the summer months, and is cut in the latter part of July, during August, and in the early part of September, three cuttings being made during the season. The third cutting yields the greatest percentage of oil and menthol crystals. The leaves are steamed and pressed in barrels by the planters, who then ship them to the menthol factories, of which there are 34 in various parts of Japan. There the oil is extracted from the leaves by a process of freezing and pressing.

Attempts have been made at various times to introduce the living plants from Japan into the United States, but so far unsuccessfully, as they cannot stand the voyage. Measures are now being taken to obtain the seeds, but these are very scarce, as the plant is usually propagated from root cuttings.—*U. S. Com. Rep.*

Thimbles Are Scarce

THE war is responsible for a dearth of metal thimbles. France, Italy, Spain and Portugal are absolutely without supplies. Before the war, Lille, Nuremberg and Vienna manufactured thimbles for all those countries, and there are only four manufacturers in England—three at Birmingham, and one at Redditch—but the metal shortage has brought their business almost to a standstill. The trade does not consume a great weight of metal, but the number of thimbles on order looks formidable enough. France alone is in want of 450,000 gross.

Zirconia as a Refractory

By E. H. Rodd

ONE of the most difficult problems associated with all high-temperature work, whether in the laboratory or the factory, is the provision of suitable refractory materials which will both withstand high temperatures and at the same time resist the chemical action of molten materials and of gases. In fact, the limit of high temperature attainment is set by the limit of endurance of the refractory. All the best known refractories, fireclay, magnesite, silica, carbon or graphite, have serious limitations, thermal or chemical, and it is of the greatest importance to our industries that any possible new refractory should be given the closest study. Zirconia has long been known as an oxide of great chemical stability and resistance to heat, but only within the last few years has its employment as a refractory material come within the range of commercial possibilities. Formerly known only in the combined state in the form of zircon, a widely but sparsely distributed zirconium silicate, and in a few other rare minerals, large deposits of the oxide have lately been discovered in Brazil.

A short account of these deposits may be of interest to the reader. They are situated in the Caldas region, some 130 miles north of S. Paulo city, and cover an extensive mountainous plateau, about 30 miles long and 15 miles wide. The mineral, known as zirkite to distinguish it from another Brazilian ZrO_2 mineral, baddeleyite, occurs in two forms, firstly as alluvial pebbles ½ to 3 in. in diameter, known as "favas," containing 90—93% ZrO_2, and secondly in the form of hard masses of light grey to blue-black ore, carrying 73—85% ZrO_2. On closer inspection, the zirkite appears to contain three distinct minerals, the oxide brazilite constituting the main bulk, with smaller quantities of zircon and a second unnamed silicate. (See H. E. Meyer, Wileman's Brazilian Review, 1916, p. 826.)

Before the possible applications of this material as a refractory are discussed, the properties of pure zirconia, ZrO_2, must first be considered. Zirconia is one of the most refractory oxides known, its fusing point being in the neighborhood of 3,000° C. Even when containing about 1.25% of silica and ferric oxide it does not melt below 2,560° C. The thermal conductivity of the pure fused material is very low, and it has a very low coefficient of expansion, 8.4×10^{-7}, which compares very favorably with that of carborundum (6.58×10^{-6}) or alundum (7.1×10^{-6}). Such a substance can clearly withstand sudden changes of temperature without fear of fracturing. Chemically, zirconia is extremely inert, being highly resistant to acids, fused alkalies, fused quartz or molten glass. No other material known to the chemist possesses such a combination of desirable refractory properties. These very properties have so far hindered its immediate development on account of the difficulties encountered in working such a material. These difficulties, however, are being slowly surmounted. One undesirable property of zirconia must here be mentioned, namely its tendency under certain conditions at high temperatures, in the presence of nitrogen or carbon, to become converted into nitride or carbide.

The utilisation of zirconia as a refractory can be regarded from two points of view, that of the laboratory and that of the works, and further it is necessary to consider, especially from the industrial standpoint, whether the crude material can be used or whether any purification is essential. For experimental purposes in the laboratory the question of cost can be left out of consideration, the desideratum being the purest and most resistant material, thermally, physically, and chemically, which can be obtained. The question to be decided is whether zirconia can be used for the construction of apparatus superior for certain purposes to that already available.

When we come to consider the materials available for the construction of such articles as crucibles, gas-muffles, and all gas-fired furnaces, tubes for electric resistance furnaces, arc furnaces and the like, the range is found to be very limited. Apart from platinum and tungsten, suitable only for small crucibles, etc., and porcelain, the use of which is limited by the softening temperature of the glaze, we have fire-clay, various graphite-clay mixtures, fused silica, magnesite, alundum, graphite, compressed carbon, carborundum, and very few other materials. All these have serious limitations from which zirconia does not suffer. Zirconia is more infusible than the best of them, is not affected by an oxidising atmosphere as are graphite and carbon, is not attacked by alkalis as is fused silica, nor by acids, as are magnesite and alundum, and is resistant to fluxing, although, of course, at very high temperatures it is readily fluxed by an oxide like magnesia. There is no question that zirconia crucibles, for example, would be superior for many purposes to any of those now obtainable, and on account of its low thermal conductivity it would contribute greatly to the efficiency of furnaces of all types if used as a lining.

The early attempts in Germany to make satisfactory zirconia ware were not so successful as was anticipated, the finished articles frequently developing cracks. This fault was due to the extremely high firing temperature required to get a fully shrunk body and to the difficulty experienced in finding a suitable binder. The publication of numerous papers on the subject within the last three years shows that the Germans are still persevering with their experiments; doubtless they still hope to have access to the Brazilian raw material after the war. They have a shrewd conviction that the importance of zirconia is going to increase.

Crucibles of zirconia appeared in Germany some years ago. Their use for melting quartz was patented by Heraeus in 1906 (D.R.P. 179,570), and according to Riecke (Z. angew. Chem. 1910, 23, 1019) they had been for some time made by the Kgl. Porzellan-manufaktur, Berlin, starch and wheatmeal being the binders employed, the crucibles being fired in a porcelain kiln at 1,450° C. It is clear that pure zirconia cannot have been used for the crucibles, as this will not frit at anything like so low a temperature. Unfortunately specimens of these crucibles are not procurable for examination. The fact that manufacturers were able to produce these crucibles while the chemists, according to their published accounts, failed to produce satisfactory articles, indicates that the solution of such a problem demands in addition to scientific knowledge the skill and technique of the trained potter. The chemical work which has been published is, however, of considerable interest. Bayer (Z. angew. Chem., 1910, p. 485) purified crude zirconia by extraction with hydrochloric acid, and to render this material plastic added 5 per cent. of pure zirconium hydroxide with starch solution as a binder. The carefully dried moulded crucibles were fired in a Hempel resistance furnace at 2,000° and very hard crucibles were said to have been obtained. Ruff (Z. anorg. Chem., 1914, 86, 389) found that the addition of 3 per cent. of magnesia to pure zirconia greatly increased the strength of zirconia pots, besides reducing the shrinkage temperature to about 1,450° C. Using 6 per cent. borax he obtained vessels showing great strength right up to the fusing point, but the shrinkage temperature was high, and even after firing at 2,200—2,400° C. the pots were porous. Weiss (Z. anorg. Chem., 1910, 65, 220) used up to 10 per cent. magnesium oxide, with phosphoric acid as a binder. He found that his pots needed to be dried very slowly after moulding, or they were almost certain to crack during firing. Many other admixtures such as plastic clay, cryolite and fluorspar were tried by Ruff but were found to be unsatisfactory. Pots containing clay lose shape and blister badly at 1,900° C. owing to decomposition of the clay, a very undesirable property. The same worker (*l.c.* 1916, 97, 73) investigated the effect of adding certain other oxides to zirconia in small amounts, in particular some of the rare earths. The addition of 1 per cent. of alumina gave good results with a firing temperature of 2,000° C., while with 1 per cent. thoria 2,200° C. was attained, and with 1—3 per cent. of yttria 2,400° C. The most promising results are obtained, however, if the zirconia is first fused. Pure zirconia, made *e. g.*, by ignition of a basic sulphate, forms a very loose powder, and articles made from this shrink enormously when fired. The oxide can be fused in an arc furnace to a compact, extremely hard mass, very difficult to grind, but articles made up from the ground material practically do not shrink at all, and consequently are not likely to crack. Podszus (Z. angew. Chem., 1917, 30, i, 17-19) claims to have made very successful porcelain-like ware with this fused material. Perhaps his most interesting claim is for a furnace made of this fused oxide in which, firing with gas and oxygen, temperatures of 2,400—2,500° C. were obtained. This is a startling achievement for a gas-fired furnace, and the development of such a furnace would practically solve the problem of firing zirconia ware.

The above brief remarks indicate the possibility that we may hope soon to have zirconia laboratory apparatus as superior to fused silica ware as the latter is to glass ware. Whether zirconia can also be introduced as a refractory on the large scale depends upon considerations of expense. If the increased cost of the new refractory is balanced by greater length of life, more continuous working and less loss of time and expenditure of labor for repairs, the success of zirconia is assured. The refractory properties of the crude material as it comes on the market are very high, although of course inferior to those of pure zirconia. It is supplied as a heavy reddish-brown powder, density 4.4—5.3, most of which will pass through a 90-mesh sieve. According to an analysis by Wedekind (Ber. deutsch. Chem., 1910, 43, 291) it contains about 68.9% ZrO_2, 14.08% $ZrSiO_4$, 12.22% SiO_2, 3.6% Fe_2O_3, 0.6% TiO_2, and some more recent analyses by the writer gave almost identical results. This crude material could undoubtedly find many useful applications, especially where the presence of so much iron is of no consequence. The choice of a suitable binding material is of first importance, since it is necessary to bring about fritting at only a moderately high temperature, without unduly reducing the refractoriness. It is said to have been used very successfully as a lining for Siemens Martin steel furnaces, water-free tar being used as a binder. Owing to the long life of such linings the cost of maintenance is very low. The zirconia can also be made up into bricks of great hardness and strength, so that for some purposes it may perhaps take the place of silica bricks, which are very brittle and frequently give trouble. The zirconia bricks, however, need a high firing temperature. Some such bricks, of which the writer has had experience, seemed to have been seriously underfired.

There are many other directions in which zirconia may find application. The recent astonishing development of electric furnaces for metallurgical processes has brought the question of refractories into prominence, and in the connexion zirconia may fulfill all requirements. In the pottery and glass industries, too, there are probably many purposes for which a better refractory is desirable. Obviously there is scope here for much research, of a kind which should be taken up by the Committee for Scientific and Industrial Research, and this, we believe, is actually being done. Doubtless, too, enterprising manufacturers and users of refractories will, when the desirable properties of zirconia become known to them, carry out experiments with it on their own account.

For some industrial purposes a purer zirconia, in particular one free from iron, is likely to be required. For example, in the manufacture of glass, and especially optical glass, it is essential that the material of which the pots are composed shall not contain iron which may be dissolved out by the melt. The separation of iron from zirconia is a task of no small difficulty, and it is fairly certain that iron-free zirconia will be available only for special purposes on a large scale. Experiments made by the writer showed that rather more than half the iron in the crude zirconia can be removed by treatment with acids. A complete separation from iron and other impurities can only be obtained by bringing the whole into solution, *e. g.*, by means of hydrofluoric acid, and treating the resulting solution by special methods. A process which was worked out and patented (Eng. Pat. Appl. 1440, 1917) consisted in precipitating a basic sulphate free from iron by partial neutralisation of a sulphuric acid solution with ammonia. An interesting outcome of this work was the discovery of a new series of basic zirconium salts, which bring out in a striking manner the analogy between zirconium and tin. (Chem. Soc. Trans., 1917, 111, 396, and Chem. Soc. Ann. Report, 1917, p. 50.) Other processes for separating zirconia from iron have been patented, *e. g.*, in Eng. Pat. 9153, 1913, a neutral solution of mixed chlorides or sulphates is heated under pressure, when the zirconium salt is hydrolysed and precipitated as hydrated oxide, iron, aluminium, etc., remaining in solution. The hydrate or basic salt thus prepared can be ignited to oxide and afterwards fused or treated in any desired manner. The purified zirconia will be needed for such purposes as laboratory apparatus, for use in enamels, into the composition of which zirconia is being introduced, and perhaps for certain special industrial purposes.—*Jour. Soc. Chem. Ind.*

Effect of Phosphorous on the Qualities of Soft Steel

IN a paper presented at the recent meeting of the American Iron and Steel Institute, Mr. J. S. Unger, of the Central Research Bureau of the Carnegie Steel Co., gave the results of experiments carried out with a view of determining the effect of phosphorus on the physical properties of soft steel bars. The results show that in soft steels an increase in phosphorus of 0.01 per cent is equivalent to an increase in tensile strength of about 850 lbs. per square inch, which is practically the same as would be obtained by increasing the carbon 0.01 per cent. Hence, high-phosphorus but low-carbon steels can be used for various purposes, provided the carbon content is decreased sufficiently to compensate for the increased hardness due to phosphorus. None of the steels showed brittleness under cold working, due to the phosphorus.

The Ignition Temperature of Gaseous Mixtures

THE determinations of the ignition temperatures of gases, made by various investigators by various methods, have yielded widely divergent results. It could hardly be different. For the very conception of ignition temperature is indefinite, and we do not know of any generally-accepted, exact definition of that temperature. We have to distinguish between combination of gases, which is frequently luminous, and their ignition, and the demarcation line is by no means sharp. If we take the case of hydrogen and oxygen, we read in textbooks that the two pure gases, when cold, may be kept in contact with one another for years without combining to any appreciable extent, even in the light, while the mixture of hydrogen and chlorine, inert apparently as long as kept in the dark, will explode as soon as exposed to strong light. The probable reason of the sluggishness of the gases is that the molecules of gases have first to be dissociated into atoms before they will combine. The dissociation may be accelerated by heat, by catalytic agents, and in other ways. At 300 deg. C. hydrogen and oxygen will already combine noticeably, about 500 deg. the reaction becomes rapid, at higher temperatures it becomes instantaneous and explosive. It is this latter temperature that the experimenter wishes to determine. But it is clear that any general statement as to ignition temperature remains indefinite unless the experimenter specifies the experimental conditions as to gas pressure, proportions of the constituent gases, mode of ignition, kind of apparatus, &c. The final heat balance of the combination will be the same, whether the combination be slow or rapid. But the momentary heat effect will depend upon the rate of combination, and that heat effect and its possible consequences in causing fires and explosives constitute the practical value of the experimental determination.

What, then, is the ignition temperature? According ot Professor H. B. Dixon it is that temperature to which the gases must separately be heated so as immediately to inflame when brought into contact with one another. The definition is one of the best given; it does not fit all cases, however. When a gaseous mixture is ignited by a spark, the gases are generally cold, the heating is momentary and strictly local, and it depends upon many factors whether or not the flame will be propagated. The feeble spark of an electric bell circuit may fail to produce inflammation, where a powerful spark of a circuit of considerable capacity will cause an explosion; the violent agitation of the gases produced by the strong spark, the sputtering of metallic particles from the electrodes, and other factors may help to propagate the flame. The temperatures of the sparks can hardly be measured. In either case, however, the flame will not spread, unless the mixture be of certain proportions; with both too little or too much methane in mine air, *e. g.*, an explosion will not take place. In the old Döbereiner lamp a jet of cold hydrogen gas impinging upon spongy platinum is so energetically absorbed by the spongy metal, that it catches fire. The temperature of the glowing platinum could be measured; but the observed temperature would be the consequence as well as the cause of ignition of the jet, and it would not indicate the ignition temperature. In experimental determinations of ignition temperature powerful catalysts like spongy platinum are not present, of course; but we have to confine the gases in some vessel, and the walls of the containing vessel, be it of glass or porcelain or metal, all exert a certain surface action or catalytic influence, especially when the gases are heated, and it is impossible to exclude these effects altogether.

Most of the experimental work has been done on hydrogen and, if we confine ourselves for the present to these gases and to the last thirty or forty years, mainly by four methods. Victor Meyer and his collaborators and, later Emich, plunged a bulb containing the mixture of hydrogen and oxygen into a bath kept at constant temperature; the observed ignition temperatures ranged from 518 deg. to 608 deg. C. The objections to the method are that the hot gases have been in contact with one another and with the walls before being fired, and that the gas pressure, originally of one atmosphere, would rise to about three times its value in the hot bath. In the second method a stream of the mixed gases is passed through a tube lying in the bath, which is gradually heated up; by this method the following ignition-points in degrees Centigrade were found: Mallard and Le Chapelier, 550 deg.; Bodenstein, 653 deg. to 710 deg.; Mitscherlich, 674 deg.; V. Meyer and Freyer, 700 deg., Gautier and Helier, 845 deg. The very high values of Gautier and Helier show the strong influence of catalysts and surface action; they packed their tube with pieces of glazed porcelain. Apart from this point the hot gases were long in contact with one another and with the hot walls while streaming. The third method, applied by Falk on the suggestion of Nernst, with special regard to compression phenomena, compressed the gases adiabatically until ignition ensued, the temperature being calculated, not observed; Falk's values ranged from 518 deg. to 569 deg. for pressure ranges from 35 atmospheres to 70 atmospheres, so that the results are not directly comparable to those of the other methods.

The fourth method of H. B. Dixon and H. F. Coward seems to offer several advantages. The apparatus consists of two concentric vertical tubes. The outer, porcelain tube is wound on its outside with platinum foil, and serves as electric furnace; the inner, glass tube reaches up to the middle of the furnace, where it ends in a small orifice; hydrogen flows through that orifice, in which a thermocouple is fixed, into the oxygen passing up the outer tube. The gases are thus at the highest temperature just at the moment when they are brought in contact with one another. The mean ignition temperature observed was 585 deg. C., and this temperature was the same for hydrogen mixed with oxygen and hydrogen mixed with air; in the latter case the oxygen would be "diluted" with about four times its volume of nitrogen. But the temperatures fluctuated widely on the upper side, *i. e.*, there was no ignition below 580 deg., but the ignition-point rose to nearly 800 deg. when the relative rate of flow, and thus the proportions of the gases, were altered by altering the size of the nozzle, and when the tube and nozzle materials were changed (various glasses, rough and glazed porcelain, quartz nozzles), and the relations were not simple, the highest temperatures being observed with the slowest rates of hydrogen flow. As the gas pressure was raised from 425 mm. to 760 mm. and 1,460 mm., the ignition temperature fell from 597 deg. to 592 deg. and 567 deg.

The same four methods were used, by Dixon and by the previously-mentioned investigators, for experimenting with other gases—carbon monoxide, methane, ethane, acetylene, ethylene, ammonia, hydrogen-sulphide. On the whole, it looks as if the fluctuations had been smaller than in the case of hydrogen-oxygen; but the range of the experiments was generally not so large either. The effect of diluents (*e. g.*, the nitrogen of the air) was sometimes very small; mixtures of hydrogen-oxygen and of hydrogen-air gave practically the same results; in the cases of the hydrogen-sulphide and methane the substitution of air for oxygen raised the ignition temperature by 100 deg. or more. Before noticing the most recent research of this kind we will allude to one other method used by V. Meyer and Münch. They passed the explosive mixtures of various gases through a capillary tube to the bottom of a small glass vessel inserted in the bulb of an air thermometer; when the mixture inflamed, the air of the bulb was displaced, and its volume was measured, the ignition temperature being thus measured.

The experiments to which we proceed were published in the Journal of the Chemical Society of London, in November, 1917, by Mr. J. Wallace McDavid, of the Nobel Research Laboratory, Ardeer. In order to avoid the influences of rates of flow and of the time factor generally, McDavid works with soap bubbles. Accepting Dixon's statement that mixtures with oxygen and with air frequently give much the same results, he mixes the gas, hydrogen or other gases or vapour with air in a 10-litre bottle, and blows, with the aid of rubber tubing, a clay pipe and a stopcock, a soap bubble of the cold mixture, when his electric igniter has been raised to the intended temperature, which is approximately known from previous experiments. His ignition temperature is thus the temperature to which the cold gaseous mixture must be heated by the application of a "hot body" so as to cause instantaneous ignition. The method is peculiar, and hardly less open to objections than others. He made use of several hot bodies. His first body was a thin-walled silicon tube wound with platinum wire, 0.025 cm. in diameter, and containing a thermocouple of platinum-rhodium. When the millivoltmeter in circuit with the couple was steady, the hot body was brought up to the bubble which was still adhering to the pipe; ignition accompanied by a slight explosion was instantaneous, when the body was sufficiently hot. In the case of Rotherham coal-gas, *e. g.*, ignition would set in when the temperature of the coil reached 800 deg. C.; at 795 deg. and less ignition would not take place. In a second set of experiments the body was a semi-cylindrical piece of iron, 1.9 cm. in diameter, 3.75 cm. long, in an axial hole of which a thermocouple was inserted; the block was heated to about 50 deg. above the intended temperature and then allowed to cool, observations being taken during the cooling period. Although this body also answered, McDavid returned to his silica tube in order to study the influences of various factors. The wall-thickness of the tube was varied between 0.055 cm. and 0.0225 cm., the internal diameter between 0.157 cm. and 0.065 cm., the length between 6 cm. and 4 cm. The thinner, smaller tubes, in which the wire was more nearly at the same temperature as the couple than in the wider tubes, gave higher ignition temperatures, the range being in the case of hydrogen 712 deg. to 758 deg. When the tube was wound with eureka wire, instead of platinum wire, the corresponding temperatures were 682 deg. and 735 deg.; this indicated a strong catalytic effect of the eureka wire, favoring combination. Finally, the hot body was formed of platinum wire wound round two notched strips of mica, 3 cm. in length and 0.3 cm. wide; the couple was between the strips. With this hot body McDavid only observed the amperemeter which measured the heating current, because his millivoltmeter in circuit with the couple did not keep steady. He ascribes this unsteadiness to a possible change in zero, variation in the room temperature, or a change in the position of the couple with regard to the coil during the experiments; he does not describe his electrical arrangements in detail, however. He found that when the bubbles were larger than the usual size, 3.7 cm. diameter, the ignition temperature was lowered, and the ignition slightly retarded. On the other hand, he considers that the cooling effect of the bubble can be neglected, because the mass of soapy water was too small, and that the influence of the size of the bubble had other reasons, namely, that a slow combustion of part of the gas (in the larger bubble) took place at the lower temperatures, and by heating the surrounding gas caused it to ignite without showing a corresponding rise in the current meter. Such an explanation should have been supported by thermocouple readings, the absence of which in these cases is all the more to be regretted. As regards neglecting the bubble moisture, one may object that a piece of damp paper visibly darkens the glowing coal, on which it is placed, before catching fire. With the thin wires and tubes of the hot bodies used, a cooling effect was not unlikely, and the retardation of the ignition seems to suggest some cooling, in fact. Mr. McDavid, however, attaches more importance to the separation of the couple from the coil, for which reason he modified his hot body as stated. The influence of the moisture in the gases he also disregards; Dixon did not find it important in several cases.

We give in the following table some of McDavid's ignition temperatures in deg. C. in the McD. column, together with a few values of others, D. and C. meaning Dixon and Coward, M. meaning Meyer:

	McD.	D. and C.	M.
Hydrogen-air	747	(already given)	
Carbon monoxide-air	931	637 to 658	650 to 730
Ethylene-air	1,000	500 to 519	530 to 606
Methane-air above..	1,000	556 to 700	606 to 678
Petrol (fraction 0 deg. to 80 deg.)-air...	995	—	—
Benzene-air	1,062	—	—
Ether-air	1,033	—	—

It should be noted that McDavid's figures always concern mixtures with air, while the other values concern mixtures with oxygen. Even remembering this the new values appear high. McDavid's method is, in a certain sense, intermediate between the electric spark methods, which are generally used for detecting the limits of explosibility of certain gas mixtures, and the other methods described. For the present it looks as if we must be satisfied with the fact that different methods will give different ignition temperatures.—*Engineering.*

Leather Preservation

SOME weeks ago there was some discussion as to the energy relations of sugar solutions. As the subject of solution has concurred with some experiments on the lasting properties of leather, I would point out that nearly fifty years' that may be taken as some standard duration, is a limit to the tanning of leather used for bookbinding at that time. As permanence is a desideratum, briefly alluding to these experiments that refer to sugar solution as confirming a mechanical theory of solution in which the heat of solution follows an atomic equivalence with fair approximation to scientific accuracy, I would mention that a leather preservative which at the same time can be an effective finishing to leather may be found in the fatty acids of linseed oil, and that in tanning processes we are dealing with complicated processes of solution, in which in our present state of knowledge the heat relations of the said processes tend to be too complicated for effective technical control in procuring the desired result.—*J. C. Thomlinson, B.Sc., in Chem. News.*

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Cutting logs into veneers preparatory to making match splints

Cutting a pile of thin veneers into match splints

How Matches Are Made

Ingenious Machinery That Produces Them Cheaply

ONE of our daily necessities to which little thought is given is the match, and it would be interesting to know how many millions of these little fire producers are consumed in the world every day, for the number must be enormous.

No one knows who discovered the art of making fire, for it appears to be as old as the human race, although the records of some very early travelers make mention of tribes who were entirely ignorant of fire. The early methods of producing fire were of two kinds, either by striking two suitable mineral substances against each other, or by rubbing two pieces of wood, one against the other. In either case it was the friction of the two piecas of material that generated enough heat to ignite some fine, dry material, such as grass or punk, the method employed resulting from the material most readily obtainable. Some peoples have used two pieces of hard stone, such as flint or quartz, which were struck together to produce a spark, which was caught on a little bunch of dry grass. In Alaska we are told that the natives rub the native sulphur, which is found in that region, over two pieces of quartz, which they strike together to produce fire, while the Esquimos strike a piece of quartz against a lump of iron pyrite with the same result. Where suitable minerals are not available we find people producing fire by friction between two pieces of wood, and this method is still in use in some parts of the world, an instance being noted in the last issue of the SCIENTIFIC AMERICAN SUPPLEMENT. And we are even told that fire can be produced by striking together two pieces of bamboo, the silicious character of the outside coating being such that sparks are produced, the same as if two pieces of flint were used.

Compared with the antiquity of the knowledge of fire making, the match is of quite recent invention. It is said that the first match was produced in 1680, when spints of wood, dipped in sulphur, were ignited by friction with a bit of phosphorus, apparently much after the manner of a modern match. But the phosphorus was too costly at that time for general use, and probably there was also too much danger of accidents in the use of this material. The effort was not a success, and the first apparently practical match was produced about 1807, when a French experimenter produced a match made of a slip of wood, a portion of which was coated with sulphur, and the end tipped with a mixture of potassium chlorate and sugar. This match was ignited by being brought in contact with sulphuric acid, which caused the sulphur and sugar to burn by the rapid decomposition of the chlorate, and from this time the development of the match began. At first the ordinary yellow phosphorus was generally used, but as it is a dangerous poison, much disease resulted among the workers in match factories. This difficulty was later overcome by the development of a modified form of phosphorus, and now the red, or amorphous form is generally used.

It is but natural that machinery should become an important factor in the making of matches, and necessarily so on account of the enormous numbers that must be produced to supply the daily demand of the world. But although America took the lead in the development of this machinery, the United States does not produce enough matches to meet its home demands, and for years we have had to look to Sweden for a large portion of our supplies, for Sweden had plentiful supplies of material suitable for making the splints, and her labor was cheap. Of late Japan has entered the match-making field, and is sending large quantities of matches all over the world, although the matches she turns out are not as good as those heretofore made either in America or in Sweden, but as the price asked is low, Japan is steadily widening her market.

In the early days of match-making the wood for the splints was sawed into blocks, and then split into the little splints we are familiar with, but the latest and most rapid method is to cut the logs of wood into a thin veneer, and then to cut the splints in enormous numbers from a number of layers of veneer piled together. These processes, as well as several others, are clearly shown in the accompanying photographs. And it may be remarked here that, although the process of making matches is comparatively simple, without the aid of very ingenious machinery it would be impossible either to supply this very necessary article in the great quantities required, or at so reasonable a price as they command in the market today.

From the cutting machine the splints are sent to kilns where all moisture is dried out and they drop down stairs to an apparatus that straightens out the splints and lays them in straight piles. The splints are then automatically stuck into square frames that are attached to endless chains that run slowly through the dipping machine. Ordinarily the splints are first dipped in paraffin in such a manner that about one-fourth of the outer end is immersed, following which they are tipped with the ignition compound, which is applied in two operations. The composition of the first dip is made up of potassium chlorate, glue, glass powder and filler, which is poured into a trough into which a slow moving roller dips, and picks up the composition on its surface. As the endless chain of the dipping machine carries the frames of splints along the ends of the splints come into contact with the coated roll, and receive the first dip. Then the carrying chains move slowly up and down over a series of rollers, in order to allow the first coating to dry before applying the second dip. The second dip consists largely of chlorate of potash, red phosphorus, glue and some filler, and after this is applied the frames are again carried forward slowly until the composition is dry, when the matches are automatically forced from the frames and sent to the packers.

Millions of match splints being discharged from the drying kiln

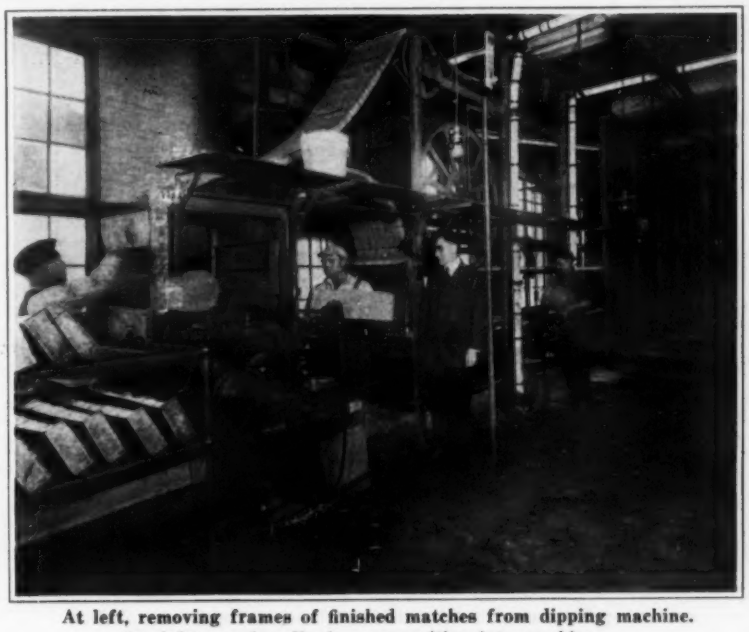
The above is a general description of the process of making a match; but there are many variations in detail, and also in the composition used. Sometimes the splints are given but one dip, in which case the compound used is made up of all of the materials mentioned above; and a variation of the method is to soak the splints in a solution of sulphate of magnesium, alum or sodium phosphate before dipping in order to prevent the burned stems from smouldering Safety matches are made in a similar manner to the above, but in these the match carries no phosphorus in its head and in order to ignite it the match must be drawn over some surface coated with phosphorus, such as is found on all boxes of safety matches.

Several times during the last two years a famine in matches has threatened this country, but the timely arrival of shipments from abroad have tided us over.

Synthetic Rubber

THE best test for this, that it cuts like leather, can be confirmed by dissolving in coal tar naphtha.—*Chemical News.*

Laying the splints preparatory to dipping, and inserting them into frames for dipping machine



At left, removing frames of finished matches from dipping machine. At right, pouring dipping composition into machine

Antiscorbutic Principles in Limes and Lemons

THE lime juice now issued to the Navy and Army for their use as a preventive of scurvy is the juice of the sour lime (*Citrus medica*, var. *acida*) grown in the West Indies. To it has long pertained the reputation made in the Navy 125 years ago by the "lime juice" used then. But that "lime juice" was not the juice of the sour lime.

The citrous fruits first used by the Navy came from the Mediterranean, largely from Spain. They did not include the *sour* lime, which is not grown in Europe; they did probably include the *sweet* lime (*Citrus medica*, var. *limetta*), but consisted principally of lemons (*Citrus medica*, var. *limonum*). In 1796 the war cut off Spain as a source of supplies and lemons were brought from Lisbon; the supply was uncertain, insufficient, and very expensive until 1803, when contracts were first made through the naval representative at Malta. Thereafter, for many years, an annual contract secured an ample quantity of the juice of lemons grown in Malta and Sicily. This enabled the Admiralty to employ "lime juice" much more widely than had been done before, and for some years the issue was a general one and not confined, as before, to the sick and to the crews of ships on foreign service. Together with the improvement in victualling and in the general conditions of living on board ships of war this was successful in expelling scurvy from the Navy in the course of a very few years, and by 1810 the records of scurvy cease. From that time the disease has occurred only in isolated and exceptional cases.

Before the middle of the nineteenth century complaints were made about the quality of the lemon juice sent from Malta, but by that time opportunities for the trial of it therapeutically were rare in the ordinary service of the Navy. On the return of Sir James Ross from the Arctic regions in 1849, however, it was shown what disastrous results might follow from a deficiency in the supply. In order that other ships then about to leave England on Arctic service should be assured of a reliable protection from diseases the Medical Director-General caused lemons to be squeezed at Deptford for them, and this provision proved fully adequate. Arrangements were made for the careful supervision thenceforward of all lemon juice bought in Malta.

About 17 years later, when the development of the lime cultivation in the West Indies made available a quantity of lime juice, the Admiralty transferred its contracts, and thereafter issued the juice of limes instead of that of lemons. The essential inferiority of limes to lemons in antiscorbutic power was not suspected, and the new supply was believed to be far better than the old. It was produced by English firms under such conditions as would secure its soundness and purity.

Polar exploration again provided the test of its value; and by comparing the experience of the ships provided with the pure lemon juice in 1850 with that of the first Arctic expedition that took out West Indian lime juice we get a very satisfactory human experiment demonstrating the relative value of the two fruits. The setting of the comparison is made more precise than is generally to be looked for in historical evidence by the following facts:

The lemon juice for the 1850 expedition was prepared at Deptford, and much attention was paid to the best method of preserving it and for obtaining its maximum value when consumed at sea. The juice was issued to the ships under regulations which insured accuracy and definiteness in the quantity consumed by each member of the crew. The daily ration, 1 oz., was issued to each man individually, and drunk by him in the presence of an officer. In 1875, when Sir George Nare's ships, the *Alert* and the *Discovery*, sailed to discover the North Pole, Sir Alexander Armstrong, who had been medical officer on the *Investigator*, was Medical Director-General of the Navy. So satisfied had he been with the results of lemon juice during the voyage of the *Investigator* that he gave directions that the juice should be issued in precisely the same way on the *Alert* and the *Discovery* as on the previous expedition, that is, in the same quantities, and with the same safeguards against any variation in the consumption of it. But the juice issued to Nare's ships was the "lime juice" from the West Indies.

The two expeditions were so near to one another in time that the general conditions of diet, &c., were very similar; but the later one did enjoy certain improvements of diet suggested by accumulated experience, including double vegetable and fruit rations, additional meat, sugar, &c., and a reduction in the amount of alcohol allowed. In casual supplies of fresh game and herbs there was no outstanding difference. Indeed, every detail of the conditions is very nicely adjusted for the comparison, any difference there was being in favor of the lime juice ships.

And the result was not only clear, but emphatic. Nare's ships, supplied with West Indian lime juice, went out in May, 1875; they had their first case of scurvy in January, 1876. Premonitory scorbutic symptoms showed themselves in a further number of the crews in early spring, but they were not recognised, as scurvy was never thought of as a possible danger. With the starting of the sledge expeditions early in April, 1876, scurvy developed with great severity in the sledge crews and three deaths occurred; concurrently there was a development, only less serious, among the men who remained on the ships. The expedition came home to England in October, 1876.

On the other hand, the *Investigator*, supplied with lemon juice, left England in January, 1850, and got into the ice during the following summer. Throughout the next winter and the spring sledging she had no scurvy. In autumn, 1851, her rations were reduced to two-thirds and her lemon-juice ration was halved, and she still had no scurvy through the following winter and spring. Only in May, 1852, her first case developed, 27 months after leaving home and after seven months of short rations and reduced lemon juice. Other 15 months passed before her crew were rescued, and in that whole period of three and a half years she had three deaths from scurvy, the same number that occurred on Nares's ships within one year.

The conclusion suggested by the history of this long immunity from scurvy during the voyage of the *Investigator* is supported by the history of other ships of her time, while the failure of the lime-juice ration to prevent scurvy on the *Alert* and the *Discovery* is repeated in later cases where it has been relied on as a protection. In the absence of any other satisfactory explanation of the contrast afforded by the experience of these two expeditions—and the prolonged examinations of the Scurvy Commission of 1877 discovered none—*it must be accepted as a very convincing piece of evidence that lemon juice is far more effective than lime juice in the prevention of scurvy. It fully confirms the results of the laboratory experiments which have determined more exactly their relative value for this purpose.—The Lancet.*

Method of Standardizing the Fastness of Colors to Light

THE method is based on the measurement of the quantity of actinic light required to produce a visible change in the tone or depth of the test sample by noting the number of consecutively exposed standard strips of a quickly fading color which are completely bleached under the same conditions. A dyestuff fulfilling the desired conditions for a standard is Eosine GGF (Cassella), which quickly fades to a clear white. Strips of coarse white filter paper are steeped in a 0.1 per cent solution of Eosine, dried without rinsing, and cut into pieces 3 by ½ inches.

The samples to be tested are dyed in known proportions on cotton yarn which is wound on a cardboard strip adapted to hold 12 samples lengthwise. A stout cardboard envelope is arranged to cover one half of the row of patterns and a strip of standard Eosine paper, numbered 1, is clipped on the card. The whole is then exposed under a sheet of glass. The set of patterns is examined daily, and when the Eosine strip No. 1 has faded to a clear white, it is replaced by another, No. 2, and so on until the visible change in the test patterns is recorded.

In this way a definite measure of the quantity of actinic light is obtained independent of the variations in its quality from day to day and, if necessary, the whole set may be laid aside at any time and the exposure resumed at the point where it was interrupted. It is possible also to subdivide the results into fractions of the standard to an approximate degree. In the extended laboratory experiments and exhaustive investigations made by color specialists, the principal difficulty lies in determining the exact end-point at which the Eosine paper is completely bleached.—*Note in Jour. Soc. Chem. Ind. on an article by A. Robson in J. Soc. Dyers and Col.*

Fishes Around New York

THE American Museum of Natural History has recently made an interesting addition to its valuable Handbook Series in "Fishes in the Vicinity of New York City" (Handbook No. 7) by John Treadwell Nichols, with an introduction by William K. Gregory. The principal part of the work is taken up by a review of the various kinds of fishes that may be found within fifty miles of the city, giving a short description of each, most of which are illustrated. Besides this there are included papers on the structure and mechanism of fishes and on how to study fishes systematically, which will assist the unscientific reader and greatly increase the value of the publication to this class of people. While apparently local in its character, the work will be found of considerable interest to all students of ichthyology.

Fringing Reefs of the Philippine Islands*

By W. M. Davis

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ACCORDING to Darwin's theory of coral reefs, in the form usually presented, shores of submergence should be fronted by barrier reefs; but the Malampaya district of Palawan is not so fronted; its reefs, where they occur, belong to the fringing class, and since Darwin's time fringing reefs have been associated with stationary or emerging shores. Barrier reefs are indeed exceptional in the Philippines, in spite of the repeated occurrence of embayed shore lines on many islands, and the question therefore arises whether the theory of upgrowing reefs on intermittently subsiding foundations is incorrect or incomplete. The object of this paper is to point out that the theory, as ordinarily stated, is incomplete, and that the element needed to complete it is to be found in a seldom-quoted passage from Darwin's own writings, as follows: "If during the prolonged subsidence of a shore, coral-reefs grew for the first time on it, or if an old barrier-reef were destroyed and submerged, and new reefs became attached to the land, these would necessarily at first belong to the fringing class" (Coral Reefs, 124).

This passage may be understood as meaning that the "prolonged subsidence" of an island might be too rapid to permit reef growth, until a pause allowed the establishment of a fringing reef; and also that the rapid subsidence of an island would destroy and submerge a barrier reef previously formed around it during slower subsidence, whereupon a fringing reef would be formed on the new shore line. Thus interpreted, the passage affords a satisfactory explanation of the frequent association of fringing reefs with shore lines of submergence in the Philippines and in certain other archipelagoes, even though such reefs may elsewhere be found on stationary shore lines or on shore lines of emergence. Fringing reefs thus formed may be described as "of a new generation;" they will evidently lie unconformably on the eroded rocks of the shore belt, and their unconformity, as well as the embayments of the shore line, will indicate their association with submergence. The contact of fringing reefs with the marine sediments that ordinarily characterize a non-embayed shore line of emergence would be essentially conformable.

Whether the shores of the Philippines now for the first time have reefs formed upon them, according to the first clause in the above quotation from Darwin, or whether the existing fringes are the successors of "destroyed and submerged barrier reefs," according to the second clause, may be determined for certain islands by the abundant off-shore soundings. Thus in the case of Palawan, its embayed western coast does not descend rapidly to great depths, but is fronted by a well defined submarine platform, 20 or 30 miles wide, along the seaward edge of which a discontinuous rim rises towards but not to the surface; the rim can be most reasonably explained as an incomplete upgrowth from a barrier reef of an earlier generation on the outer margin of a broad lagoon. It is not possible, in our present ignorance of the geology of Palawan, to determine whether the drowned barrier reef was formed by up-growth during slow and long continued subsidence, or by outgrowth during a long-enduring still-stand of the island; but in either case, the great breadth of the lagoon plain appears to be the product of a long lasting process, and thus contrasts strongly with the new fringing reefs of the Malampaya district, which are so narrow as to be inconspicuous on charts of the largest scale. Evidently, therefore, the rapid submergence by which the barrier reef of Palawan was drowned must be of recent date.

Similar conclusions may be derived from other parts of the Philippines, where embayed shore lines, relatively narrow fringing reefs, and well defined submarine platforms are frequently found, although no islands are so striking in these respects as Palawan. The platforms cannot be reasonably ascribed to marine abrasion during a higher stand of the islands or a lower stand of the ocean, for the island shores are not cliff; and the submergence of the platforms cannot be accounted for by rise of ocean level, which must everywhere be of the same date, amount and rate, for the platforms vary in depth, and the new fringing reefs vary in breadth. The depth of the Palawan platform for example, increases from 25 to 30 fathoms at its southwestern end to 55 or 60 fathoms near its middle, and then decreases again toward the northeastern end; and the fringing reef, which is hardly chartable near the mid-length of the island where the platform is deep, has a width of 1 or 2 miles at the southwestern end of the island where the platform is relatively shallow.

On the other hand, the northeastern coast of Samar, on the opposite side of archipelago from Palawan, has a moderately sinuous shore line with delta flats that diminish the initial size of its bays, and fringing reefs that reach forward a mile or so from its points; here the latest submergence cannot be so recent as that of Palawan. But instead of being benched by a submerged platform, the sea bottom off shore from Samar sinks rapidly to a great depth. Moreover, there are long stretches of the coast of Luzon which are neither embayed by arms of the sea, nor enclosed by barrier reefs, nor fronted by submarine platforms: Luzon, unlike many other of the Philippines, has a considerable extent of coastal lowlands, as if the growth of fringing reefs, or the outwash of detritus, or the emergence of the former sea border had increased its now littoral area. Again, Cebu and Negros, which occupy a somewhat central position in the archipelago, are described by Becker as terraced with elevated reefs up to altitudes of 2,000 feet or more. The diverse shore features of the different islands are therefore best explained by local changes of land level, unlike in date, in direction, in amount and in rate.

It is particularly the rapid rate, the recent date, and the considerable amount of subsidence often indicated that are of significance in the coral-reef problem; and this is true not only for the Philippines but also for the other archipelagoes between Asia and Australia. Embayed shore lines indicative of submergence are common though by no means universal in all this region, but well developed barrier reefs are rare. Before the reefs of Cebu and Negros were elevated, and before the platform of Palawan was depressed, barrier reefs must have been more extensive than now in the Philippines, and possibly in the other island groups also; but today no examples of these forms are to be found in the archipelagoes that can compare with the great barrier reefs of northeastern Australia and of New Caledonia; few of the many small islands in the archipelagoes are enclosed by well developed encircling reefs, like those of the Fiji and Society groups; and atolls, which are so striking a feature of the open Pacific, are relatively uncommon in the archipelagoes.

The best explanation of the small development of barrier reefs and atolls in the archipelagoes is to be found, not in the lack of subsidence, which is elsewhere so intimately associated with reef development, for geological and physiographic evidences of subsidence abound on many islands; and surely not in the prevalence of unfavorable conditions as to the temperature and purity of sea water, for fringing reefs flourish; but largely in the occurrence of subsidence of so rapid a rate and in some cases of so great an amount, as to have submerged pre-existing reefs. Moreover the subsidences appear to be in many cases of so recent a date that the new fringing reefs are still narrow; it is presumably for this reason that the drowned barrier reefs and atolls have not yet had time to grow up again to sea level. Added to this is the frequent occurrence of recent uplifts in the archipelagoes, whereby weak marine sediments, overwashed by an abundance of alluvium from rejuvenated rivers, have come to occupy the shore line of certain islands, thus discouraging even the growth of fringing reefs, as around much of the coast of Borneo and along the southern coast of Java.

In view of these facts and inferences the Australasian archipelagoes must be considered much more unstable than the floor of the central Pacific. In that vast region, where reef upgrowth has generally kept pace with changes of level, and where atoll and barrier-reef lagoons have been filled with sediments to a moderate depth, Darwin appears to have been right in concluding that "the subsidence thus counterbalanced must have been slow in an extraordinary degree" (115).

On the other hand, the instability of the Australasian region is attested not only by the evidence afforded by coral reefs, but also as above noted, by many geological researches; those by Molengraaff and Abendanon are particularly instructive in this respect, and fully confirm Darwin's statement:—"North of Australia lies the most broken land of the globe, and there the rising parts are surrounded and penetrated by areas of subsidence" (143). Hence while Darwin's general conclusion that "the rate of subsidence has not exceeded the upward growth of corals" (115) seems to hold true for the central Pacific, it is not valid for the region of the archipelagoes. The not infrequent occurrence there of subsidences at a rate sufficient to drown coral reefs ought to satisfy those objectors to Darwin's theory who have urged that it demands too great a uniformity, if not also too slow a rate in the movements of the earth's crust in oceanic areas. But let it be noted that rapid movements of subsidence, and also fringing reefs of a new generation which are formed along a shore where rapid subsidence had drowned pre-existing reefs, were explicitly recognized by Darwin as of possible occurrence—witness the first quotation from his Coral Reefs, above.

Fringing reefs of a new generation on shores of submergence should therefore be accepted as accounted for by Darwin's theory quite as well as other fringing reefs, and indeed as contributing their share towards verifying the theory, even though its author did not recognize any actual fringing reefs as of this origin.

There can indeed be little doubt that a number of other islands also, which have unconformable fringing reefs along their embayed shores, were wrongly classed by Darwin, who took no account of embayments or of unconformities. Striking instances of this kind might be pointed out in the Solomon group, where the small island of Fauro, for example, which is described by Guppy as a deeply denuded volcanic wreck, has a shore line of marked irregularity, a narrow fringing reef, and a well developed submarine platform from 40 to 70 fathoms in depth; such a combination of features proclaims intermittent subsidence after long-continued subarial erosion, the last movement being more rapid than reef upgrowth; yet all the members of the Solomon group are colored red on Darwin's chart, because the little information he had about them gave "a presumption that they are fringed" (167). Other examples of new fringing reefs on shores of submergence are found on the granitic islands of the Seychelles in the western Indian ocean, as will be again noted below. The Andaman islands in the Bay of Bengal are elaborately embayed, and a submarine platform several miles in breadth and from 20 to 40 fathoms in depth adjoins them; a bank of similar depth, measuring 35 by 10 miles lies not far away to the east; yet these islands have no barrier reefs and only very narrow and discontinuous fringing reefs; their submergence must be very recent. If the postglacial rise of ocean level were the cause of all these submergences, reefs should everywhere be of about the same volume; as a matter of fact they vary in volume enormously. The fringing reefs of southwest Palawan, of Yap in the western Pacific, and of Rodriquez in the southern Indian ocean are two or three miles wide; various atoll and barrier reefs are half a mile or a mile wide. Others are much narrower, and still others are discontinuous, or so imperfectly developed as not to reach sea level; finally, some submarine banks are flat, without any reef rim. These irregular values speak for variable subsidence of the reef foundations, not for a uniform rise of ocean level.

The occurrence of subsidence in the Australasian region at a more rapid rate than that of coral upgrowth has an interesting bearing on the origin of the numerous submarine banks, of various depths down to 40, 50 or 60 fathoms, in the China sea. It is evident that if islands suffer a movement of subsidence rapid enough to drown their barrier reefs and thus to develop fringing reefs of a new generation, the same subsidence would completely submerge neighboring atolls. Furthermore, if the rapid subsidence of a group of islands were of so recent a date that the resulting fringing reefs are still narrow, the drowned reefs of the submerged atolls might still remain below sea level, even if the amount of submergence had not been great enough to kill all their corals.

Now in view of the proximity of the China sea to the Philippine Islands, it seems reasonable to suppose that its floor has shared some of the many movements by which the islands of the archipelago have been disturbed; hence the submarine banks of that deep basin are best explained, following Darwin's theory, as drowned atolls not yet rebuilt. The date as well as the rate and the amount of a subsidence is therefore of importance in determining whether the atolls that it drowns shall still be submerged. Certainly recent submergence, presumably due to subsidence, has affected the Macclesfield and certain other large submarine banks of the China sea, for corals are growing on the rims of many of them, but have not yet built the rims up to the sea surface. On the other hand in spite of the proximity of the unstable Philippines, the Glacial-control theory explains the Macclesfield bank, which is taken to be a typical example of its kind, as the remains of a huge volcanic cone, originally as large as Hawaii, which stood still long enough to be worn down to small relief in preglacial time, and which, still fixed, was truncated by abrasion at a lower level while the ocean was depressed about 40 fathoms during the Glacial period.

It may be noted that if the surface forms of the mid-Pacific atolls are considered alone, they can be accounted for very satisfactorily by the Glacial-control theory, which was invented chiefly to explain the spe-

*From the Proceedings of the Natl. Academy of Science.

cial features that they present; but as atolls occur in association with barrier reefs in the Caroline, Society, Fiji and other groups, and as the central islands within the barrier reefs present features which, although perfectly accounted for by Darwin's theory of intermittent subsistence, cannot be accounted for by the Glacial-control theory, its apparent success in explaining atolls is thereby discredited, all the more so in view of the recent discussion by Skeats of the boring in the Funafuti atoll (*Amer. J. Sci., New Haven*, 45, 1918, 81-90).

The chief value of the ingenious Glacial-control theory may therefore be found not so much in its postulate of the prevalent stability of reef-bearing islands, or in its assumption that reef corals were killed and that reef-bearing islands were abraded while the ocean was chilled and lowered in the Glacial period, but in the emphasis that it gives to changes of sea level from climatic causes as a factor in the coral-reef problem; for it is manifest that if the cost-glacial rise of sea level coincide in time with the subsidence of an island, the resulting submergence will be at an accelerated rate and of an increased amount; while if the fall of sea level occasioned by the oncoming of a glacial epoch coincide with a subsidence, the resulting submergence will be at a retarded rate and of a decreased amount. It cannot however be supposed that two processes so unlike in cause as external climatic changes and internal crustal deformations should be closely related in time; their coincidences must be fortuitous. Throughout the central Pacific the rate and amount of recent submergence have not been as a rule too great to be compensated by reef upgrowth; witness the abundant atolls and barrier reefs. But in the region of the Australasian archipelagoes compensation of submergence by reef upgrowth has frequently been unsuccessful; witness the rarity of well developed barrier reefs and the almost entire absence of atolls. As the climatic changes of ocean level must have been everywhere the same, the factors which have determined the success or the failure of reef upgrowth would appear to be the rate, the amount and the date of subsidence.

It may be added that submarine banks, of such form that they are best accounted for as drowned atolls, are rare in the Pacific. A group of ten or more of them is known in an island-free space north of Fiji; several extensive banks also occur in Tonga. Exception must therefore be made in favor of a rapid submergence only for these relatively few examples of submerged Pacific atolls, and the rule that the great majority of Pacific atolls have not been submerged faster than the rate of reef upgrowth is thereby proved. In the Indian ocean, on the other hand, the number of submarine banks bears a larger proportion to that of atolls, and the Indian ocean is generally regarded by geologists as the seat of greater and more recent movements of depression than the Pacific. Recent and rapid subsidences of moderate amounts may therefore be plausibly regarded as of more general occurrence in the Indian than in the Pacific ocean. The recent date and the rapid rate of subsidence appear to be of greater importance than its amount in the case of the Great Chagos bank, where the submergence does not seem great enough to drown the reef-building corals. Here the muddy central area is 40 or 50 fathoms deep; it is bordered by an irregular sandy bank from one to 5 miles or more in breadth and from 15 to 20 fathoms in depth, on the outer margin of which rises a rim about a mile in width, and only 5 or 10 fathoms in depth; singularly enough, there is little living coral on the outer rim, though knobs of growing coral rise from the central depression. The diameters of the whole mass range from 50 to 75 miles; its form suggests that a prolonged stationary period, during which a broad atoll-reef was developed, was followed by a subsidence of about 10 fathoms, after which a shorter stationary period permitted the upgrowth of a narrower reef; then a rapid and presumably recent subsidence of 5 or more fathoms ensued, since which no effective reef growth has taken place, possibly because, according to Daly's suggestion, the submerged corals were smothered by wave- and current-shifted sediments.

Unfortunately no archipelagoes comparable to those of the Australasian region are present in the Indian ocean to give evidence in the case, but it may be noted that a few high islands which occur in association with the Indian ocean banks—chiefly the granitic islands in the area of the great Seychelles bank—have narrow and unconformable fringing reefs on their deeply eroded and well embayed shores; thus they repeat in a small way the more abundant and therefore more compulsory evidence that is provided by the charts of the Philippines. Further details on these topics are given in an article on "Submarine Banks and the Coral Reef Problem," now in course of publication in the *Journal of Geology*, and in an article on the "Subsidence of Reef-encircled Islands," soon to appear in the *Bulletin of the Geological Society of America*.

Life and the Structure of Molecules

(Continued from page 51)

fluorescence and the slight rotary power of the latter. All the definite bodies which we extracted from it were found to be identical with other bodies which have been isolated from the petroleums of Canada, of California or of Galicia. We have thus proved, for the first time, that there is a relation of a chemical nature between these two natural products of vast importance, namely, coal and petroleum. Does this relation imply a common origin, and will it provide an argument for those who believe that petroleum, like coal, was of vegetable origin? For my part I believe this to be true, but to discuss the point in this place would lead me too far away from my subject.

3. If coal, as we believe we have demonstrated, is formed of a mixture of cyclic substances, we can scarcely refuse to attribute the same structure to cellulose, which, of all the substances contained in plants is certainly that which has played the largest part in the formation of coal. I am justified, therefore, in believing that the criticisms of my theory in this respect are not sustained, and that, on the contrary, my hypothesis finds a fresh example to suport it.

Let us pass now at a single bound over the entire distance which separates the primary products of vegetable assimilation and its ultimate product which is *living matter*. And let it be clearly understood to begin with that I employ this term, living matter, only by way of abbreviation and to avoid lengthy circumlocutions. We cannot attribute life to matter itself; in fact, there is no such thing and there can be no such thing as a living molecule and a dead molecule. Life necessiates an organization, which is that of the cell, and by that very fact it remains outside the domain of pure chemistry.

It is none the less true that the contents of the living cell must differ in chemical nature from the contents of the dead cell, and it is from this point of view alone that the phenomenon of life is related to my subject; and it is also from this point of view that it remains to examine whether the ideas which I have laid before you can be utilized for the purpose of its interpretation.

A living cell is an extraordinarily complex organism in its chemical composition as well as in its morphological structure. The protoplasm which it contains is a mixture of the most diverse substances; but if we eliminate, on the one hand, that portion of these substances which are in process of assimilation, and on the other hand those which constitute the residuum of nutrition and which are in process of being excreted, we have left only proteic or albuminous matters which must be regarded, if not as the essential agent of life, at least as the theatre of its manifestations. They alone, in fact, possess the two eminently vital faculties of constructing their molecules from those of their environment and of reacting to the slightest excitations, whether physical, chemical or mechanical. They rank, therefore, among the most labile organic compounds which we know, *i. e.*, they possess a sort of fluid equilibrium which is maintained by a constant shifting of matter, and it is this very lability which enables them to support the vital phenomena. During the life of the cell they are in a state of perpetual transformation and never arrive at a state of stable equilibrium until after the death of the cell; or, rather, as we might better say, the death of the cell is nothing more than the result of stabilization of the proteic molecules.

Is this stabilization chemical in nature in the sense that it proceeds from a modification of the molecular structure? To know whether this be the case and what this modification consists of it would be necessary to know the constitution of living albumen and also that of dead albumen. But chemistry is entirely or almost entirely ignorant of the first, for the first effect of the processes of investigation which it employs is to kill every living cell. The slightest elevation of temperature, the contact with any sort of solvent, and still more that with even the mildest reagents, occasion that transformation which ought to be avoided, and thus the chemist has only dead albumen left in his hands. It is only the latter, therefore, which he has been able to study. Thanks to the labors of a galaxy of eminent savants, at the head of whom we must place our two honorary members, Emil Fischer and Abderhalden, we are familiar with the constitution of the albumens, if not in the minutest details, at least along general lines. We know in particular, as respects our present point of view, that the extremely complex molecule of these bodies is formed by the assemblage of a very large number of chains, some of which are formed of atoms of carbon alone, others of atoms of carbon and of nitrogen, but all of which are closed chains. The albumens derived from dead tissues are cyclic in structure.

But the question is whether this is true of these albumens while they still form an integral part of the living protoplasm, and how we can determine it.

A highly interesting observation made by Loew will give us the beginning of an answer to these questions. Loew observed that all the chemical reagents which are capable *in vitro* of attacking the aldehydes and the primary bases, or of acting upon the aldehydic and aminogenic groups which characterize them, invariably act as poisons to living protoplasm. These same reagents, on the contrary, exert no influence upon dead albumen. From this circumstance Loew logically concludes that the molecule of living albumen contains the said groups, while the molecule of dead albumen no longer possesses them.

These two groups of atoms possess very active functions throughout the whole extent of organic chemistry. But these functions are opposite in character, which leads them to react upon each other by the exchange of the elements which compose them. This exchange does not take place in the living albumen, since in that the two groups co-exist side by side; it operates after the death of the cell, since neither of these two groups can be detected in its albumen. This stabilization of the proteic molecule must be due, therefore, according to Loew, to the saturation of one of these two groups by the other. This observation appears to me to be of capital importance; but its author has not pursued it, in my opinion, to the ultimate limit of its theoretic consequences. I will attempt to do this in his place.

By the conditions of their very nature the groups of atoms to which I refer can in no case form an integral part of a closed chain. Being both of them monovalent they are capable of forming a part only of open chains. Their existence in living albumen necessarily implies, therefore, the presence of these chains therein.

But the union of two atomic groups forming a part of the open chain cannot occur without the closing of this chain; at the same time the disappearance of both active groups also necessarily involves the abolition of a portion of the activity of the contents. It is like a man who clasps his hands together or crosses his arms; by doing this he loses the best part of his means of action. The stabilization of living albumen involves cyclization therefore. When the albumen of the cellular protoplasm closes its open chains into the ring form it enters into equilibrium and a state of rest. Its period of activity terminates in the same manner as that of all the substances which combine to maintain it. Both in the one case and the other *cyclization is death*. It is a momentary death, of course, and destined to be followed after a longer or shorter lapse of time by a resurrection which will again put in circulation the atoms temporarily immobilized. It is evident, in fact, that if all the molecules which have undergone cyclization should remain indefinitely in this state, all trace of life would soon disappear from the surface of our globe.

Therefore, all that I have said applies only to the organic compounds which form a part of the living plant. As soon as they are taken away from this other agents come into play which proceed more or less rapidly to the demolition of all the molecules and to general decyclization. The dead plant immediately finds itself engaged in a struggle with the microbes of putrefaction which attack its albumens, and with the oxidizing ferments which burn its cellulose. Or, perhaps, we behold the intervention of the digestive ferments of the herbiverous animals which are likewise cyclolytic. Here, as elsewhere, the two kingdoms complete and mutually assist each other, and it is the same atoms which, passing from one to the other in aggregates of various srtucture, maintains the eternal existence of both.

Such are the ideas which I have felt myself able to lay before you concerning the relations which exist between molecular structure and life. I have lifted but a small corner of the veil which hides the mystery, but I believe I have succeeded in answering the three questions with which I began by showing:

1. That the vital phenomena are connected with a special structure of the organic molecule;

2. That only the arrangement of the atoms in open chains permits the manifestations of life and its maintenance;

3. That the cyclic structure is that of substances which have lost this faculty;

4. And finally, that death results, from a chemical point of view, from a cyclization of the elements of the protoplasm. The serpent holding its tail in its mouth, which was the symbol of eternity among the ancients, might be regarded as that of death by the modern biochemist.

I have spoken to you only of the chemistry of the plant. It remains to be seen whether my interpretation can be applied also to the phenomena which take place in the animal organism.

Taking Photographs from Airplanes and Balloons*

Some Special Cameras Developed to Meet Unusual Requirements

By Lieut. J. A. Lefranc

In trench warfare the chief object of an aerial squadron is the study of the manner in which the enemy has organized his lines and positions; in open fighting, on the contrary, the importance of scouting by the aviation service is considerably greater. In this case its task is observation of the enemy and the warning of the general staff against strategic surprises which might cause inevitable disaster. Modern methods of transport by motor trucks have given so much flexibility to the movements of the troops that all the great concentrations take place at considerable distances from the fighting line, even at distances of from 100 to 200 kilometres behind the front.

It is only the scouts of the air who are able to obtain accurate information as to these movements, since the documents furnished by the intelligence service are not always reliable. The Germans have just given proof of the very great importance which they attach to aerial reconnoitring by creating in their armies squadrons for this purpose alone. These squadrons are provided with an especial type of airplane manned by picked men.

The utilization of aerial scouting by means of the direct view of the observer is impossible because of the high altitude, except as regards very general features—thus, observers can readily watch the activities of railroads, both as to the number, direction and importance of trains and as to the operations in and around stations. They can also watch the movements of troops and convoys over roads, and they try to form a general idea of the degree of activity in a sector by the observation of villages, cantonments, camp fires, assemblages of vehicles, etc.

This utilization of direct sight is well suited to open fighting; the time factor, in this case, becomes of the first importance, and the visual observation of a keen and intelligent observer is worth any amount of photographic documents. In trench warfare it may be necessary for the observer to get precise information in regard to certain points; in this case he descends to a low altitude in order to devote his entire attention to the point of essential interest, an operation which could not be so advantageously performed by a photographic apparatus. The observer serves, as we see, as a means of communication between the troops engaged in the battle and the organizations at the rear who must know their precise position either to provide them with supplies or to protect their advance by means of artillery. The communication between the infantry and the avion in such a case is made by means of Bengal fire or other signals.

The function of the observer is of great importance in the regulation of artillery fire Quite recently the Germans have extended this rôle so as to include the survey of the field of battle; the *Ueberwachungsflieger* (Flying surveyor) flies above the terrain and searches for moving objects such as tanks, supporting batteries, marching reinforcement troops, etc, in order to point them out to the artillery and direct the fire upon them.

In the preceding cases, which concern open fighting or the "war of movement," the utilization of direct view enables the observer to cover an immense area of the terrain; in the case of trench warfare the advantage of the direct view consists in instantaneous observation and the possibility of immediately reporting the results to the rear by means of wireless telegraphy.

The principal difficulty in making use of direct vision for reconnoitring purposes is the intrusion of the personal factor of the temperament of the observer. Certain observers sometimes report, in perfectly good faith, vast quantities of information, a large part of which is purely the fruit of their subconscious imagination. This psychic phenomenon is very certainly due to the hypertrophy of sensation in individuals all of whose faculties are strained to the utmost. When a bombadier declares in good faith, though mistakenly, that he has seen his bombs burst in the middle of an important railroad station, the mistake is not serious, but when an observer declares he has seen the trenches of the enemy flattened out and his wire defences destroyed, if this destruction is due to his imagination the error may involve the success or failure of an attack.

Direct vision is not appreciably helped by the use of field glasses, since because of being at a height of often 4,000 to 5,000 metres their field of vision is very small, and the vibration and motion of the avion make it very difficult to find a point and hold it in the field. German airplane observers, in fact, are not provided with spyglasses.

The establishment of trench warfare and the construction by the belligerents of hundreds of kilometres of fortified positions have greatly contributed to the development of aerial photography. A photograph offers the immense advantage of containing elements which possess a strictly scientific precision. Aerial photographs enable the belligerent to know the technical organization of the lines and positions of the enemy almost to the slightest detail.

We know, for example, that when the Germans are planning to make an attack against our lines they build at the rear an exact reproduction of the French position which they intend to endeavor to carry. For several days the shock troops are trained to manoeuvre in this position and taught to know all its details. Aerial photographs reveal the trenches, the net works of barbed wire, the paths by which they are traversed, the communication trenches, the camouflaged machine gun nests, the batteries, the location of stores and munitions, the telephone lines (which are betrayed by the tracks of the men who repair them), the telephone centres, the observatories, the posts of command, warehouses, etc. We can readily understand that the knowledge of all the technical elements of the enemy positions favors offensives by allowing the commander to counteract the hostile forces and their means of combat. In the same way the knowledge of the evolution of their manoeuvres, and of the preliminary signs of attack, permit the careful preparation of the defences and the avoidance of surprises (convoys, gatherings, camps, batteries, shelters, tracks, communication trenches, aviation grounds, etc.).

The intelligent interpretation of aerial photographs is very difficult; when correctly done it enables the general staff to construct maps and plans of the enemy positions and of their organizations; photographic compensation is a veritable art, consisting in the planimetric reproduction of the photographs taken, i. e., their reconstruction on the desired scale (15,000) and finally in extensive retouching to accentuate the important elements; it permits the creation of vast photographic maps including the whole sector of an army.

Aerial photography is obliged to contend against two kinds of difficulties. In the first place, the enemy takes the greatest care to conceal his plans, and to this end makes use of camouflage as far as possible; for example, the trenches are dug in the shelter of a mat of artificial grass, tracks and roads are covered with neutral colored earth, hangars and barracks are painted in the colors of the surrounding terrain, and the avions themselves have their upper surfaces mottled with the colors of nature, etc. The belligerents endeavor to hide their cantonments and camps in the shelter of forests and woods; batteries hide in coppices, taking advantage of the fact that sensitive photographic plates register differences of one in shades of green very poorly.

The majority of the movements and manoeuvres of troops are made at night, at which time the roads are gorged with supplies and convoys; by day, on the contrary, they are occupied only by isolated vehicles or repair crews. Very often false works are set up in order to deceive the enemy; false batteries, false stations, etc.; this is because a photograph shows few details, so that these false works may be easily mistaken for the true ones, which are perhaps several kilometres distant and heavily camouflaged.

Other difficulties are of technical nature, such as the high altitude at which airplanes are obliged to fly, or the lack of precision in the sighting, or finally the small surface of the terrain covered by a plate 13 cm. by 18 cm. at altitudes of 5,000 to 6,000 metres.

The endeavor to penetrate the secrets hidden by camouflage necessitates the constant checking or "control" of a sector under observation; it is, in fact, a rare thing when the comparison of numerous views of the same point, taken at different times, does not yield some betraying sign. To detect the secrets hidden by the verdure of woods the only available means is the utilization of special yellow screens placed in front of the lens of the apparatus; this yellow screen enables the plate to register the slightest luminous details submerged in the green.

Modern aerial observation makes use of automatic apparatus to counteract the lack of precision in sighting and the small field covered. These enable the observer to expose a large number of plates, from 150 to 200, without paying constant attention to the machine

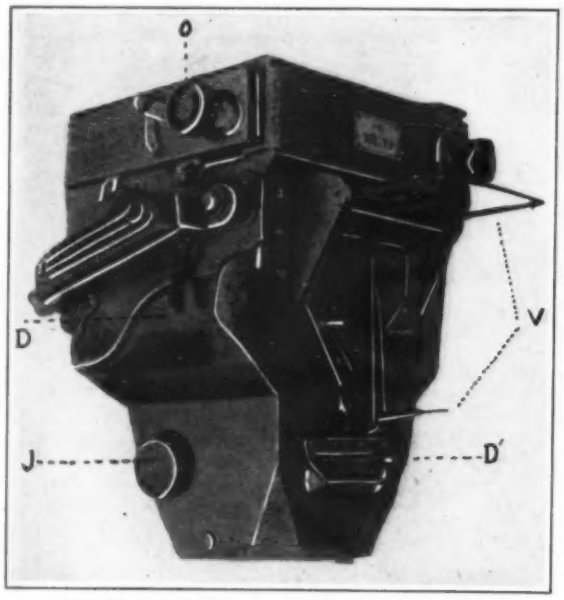

Fig. 1. Photographic apparatus with a focus of 0.25m. Ervemann patent

O. Milled head setting button. *K.* Speed dial. *H.* Device for changing speed rate. *D.* Trigger. *J.* Button of yellow screen. *V.* Sight. *D.* Diaphragm.

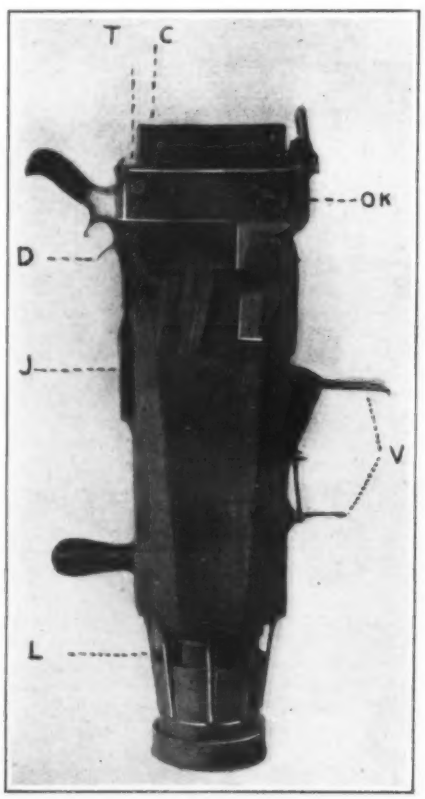

Fig. 2. Photographic apparatus 0.50 focus Ica patent

O. Setting button. *D.* Trigger. *T.* Shutter tension. *K.* Button controlling opening of shutter. *V.* Sight. *J.* Yellow screen. *C.* "Ica" Plateholder containing 6 plates. *L.* Lens.

*This article is one of the series dealing with Evolution of German Aviation, by Lieut. J. A. Lefranc of the French army; the author, who is a licensed mechanician and holds the commission of technical adjutant, is a well known authority upon the construction of airplanes and the accompanying apparatus This series which appeared in *La Nature* (Paris) has attracted widespread attention. Translations of some portions have already appeared in the SCIENTIFIC AMERICAN SUPPLEMENT.

He needs only do the sighting and manipulate a lever, which not only loads the apparatus but removes the exposed plate, inserts the unexposed plates and releases the shutter.

A still more perfect form of apparatus relieves the observer of all care except the sighting, since it is operated electrically or by means of clockwork; the film unrolls and the shutter opens at regular intervals. With this apparatus it is possible to bring back from an expedition three full magazines containing about one thousand photographs, covering a strip of territory four hundred kilometres long and 2.5 km. wide.

The problem of long distance photography was more difficult to solve. Two solutions present themselves—either the employment of telephotographic apparatus, or those with a long focus. Telephotography employs apparatus provided with ordinary lenses completed by an optical enlarging system placed in front of the lens. The chief inconvenience of this arrangement is the loss of illumination; in this case, in fact, the intensity of the light affecting the plate after enlargement is inversely proportional to the square of the enlargement. For example, the photographic apparatus in current use, having a focus of 0.2 metres, and provided with a telephotographic device giving a six fold enlargement, will produce the same image as an ordinary apparatus having a focus of 1.2 metres, but the luminous intensity received by the plate of the telephotographic apparatus would be only one thirty-sixth times as great. Under these conditions it is difficult to make use of telephotography on an airplane, if we consider that the

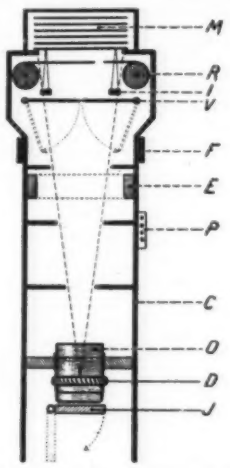

Fig. 3. Diagram of Goerz apparatus of 0.50 focus

M. Removable magazine containing 6 plates 13 x 18. *R.* Curtain shutter. *I.* Indicators of degrees of inclination. *V.* Double door opening on exposure. *F.* Clamping band. *E.* Electric coil fr heating apparatus. *P.* Connections for current used for heating. *C.* Body of apparatus made of cloth-covered wood.. *O.* Lens with 0.50 focus. *D.* Diaphragm. *I.* Yellow screen.

lenses in this case must work at speeds varying between 1/100 and 1/600 of a second, by reason of the tremendous speed attained by airplanes (forty-seven metres per second).

Long focus apparatus, on the contrary, permits the operator to make long distance photographs without loss of luminosity. Following upon numerous tests a commission formed by the War Office assembled in 1900 decided to adopt long focus apparatus for army use. Accepting it as true that the naked eye is capable of perceiving the tenth of a millimetre upon a photograph, then to perceive an object one metre in diameter and five thousand metres distant the apparatus must possess a focus of 0.50 metres ($\frac{F}{5000} = \frac{0.001}{1.00}$). This is the focal length most frequently employed in current aviation apparatus.

The inconveniences involved in making use of long focus photographic apparatus is that they are very heavy, cumbrous, and hard to handle upon avions. The German aviation service utilizes three types, having focal lengths of 0.25, 0.50 and 1.2 metres respectively; they carry plate holders containing six 13 x 18 cm. plates.

The 0.25 *apparatus* (Fig. 1): This apparatus is movable and is managed by the hand of the observer. It is made use of either for making oblique views at a low

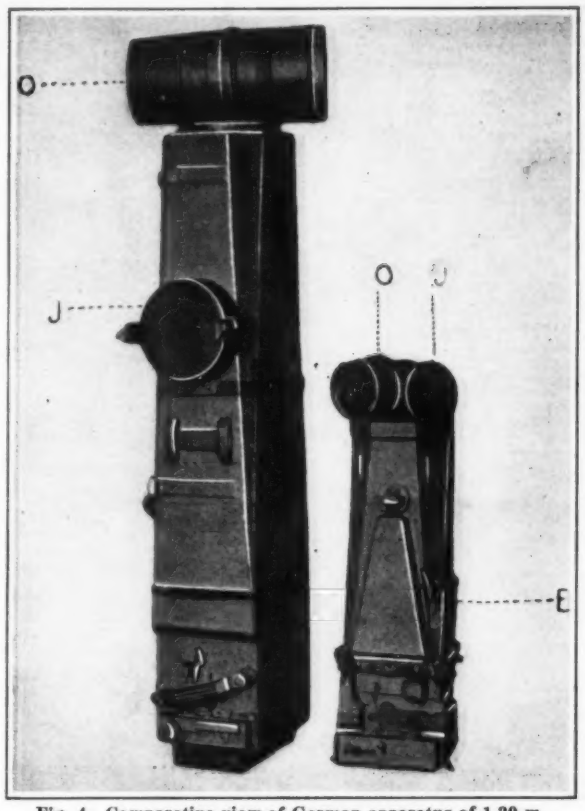

Fig. 4. Comparative view of German apparatus of 1.20 m. and 0.50 m. focus (1918)

O. Lenses. *J.* Yellow screen. *E.* Connection of current for heating apparatus

altitude or for taking photographs upon avions which are not specially fitted for the reception of fixed apparatus. They are 40 x 35 x 25 centimetres in dimension and weigh 5.8 kilograms, being made of reinforced wood covered with cloth. They are extremely strong;

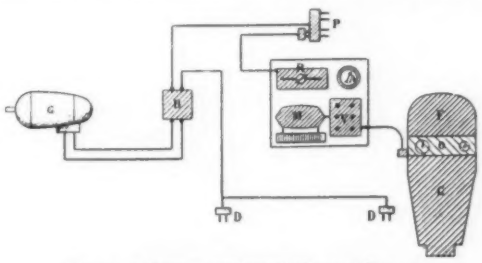

Fig. 5. Diagram of installation of Fig. 4

G. Generator connected with motor. *B.* Connection box. *D.* Connections of current for heating. *C.* Dark chamber. *F.* Magazine containing films. *R.* Rheostat. *M.* Electric motor. *V* Voltmeter. *O.* Shuttering device. *P.* Connection of current for wireless apparatus.

and generally will survive the hardest fall.

The lenses are made by Zeiss and possess iris diaphragms giving an aperture of 4.5, 6.3, or 9 and are controlled from the outside by a button sliding on a sector; a yellow screen can be interposed at will in front of the lens to permit the taking of photographs in detail in shades of green (forests, camouflage). This screen is manipulated from the outside by means of a milled head button which acts upon the screen by means of a small rod.

The curtain shutter has four slits of 3, 6, 11 and 21 millimetres respectively, corresponding to the speeds 1/750, 1/350, 1/180 and 1/90 of a second.

The tension of the shutter spring is proportional to the width of the slit, and these two factors of the speed of the shutter are controlled by the same milled head button and act as one. Behind the lens, and in the dark chamber, is a door with two leaves which is likewise controlled by the release of the shutter. The sight consists of a rectangular frame made in one piece with a guide which rises at the same time the sight does.

The apparatus has two handles which enable the observer to hold it overboard. In the interior of the dark chamber are two little devices placed in the field of the luminous rays. These permit the operator to photograph upon each exposed plate the two inclinations taken by the apparatus at the very moment when the photograph was taken. These indications are valuable to facilitate the planimetric reproduction of the oblique photograph made by this hand apparatus.

Two small pendulums of graduated glass, one in the form of a cylinder, the other in form of a disc, print their degrees of inclination upon the plate by means of small lenses which correct the luminous rays preceding from the main lens.

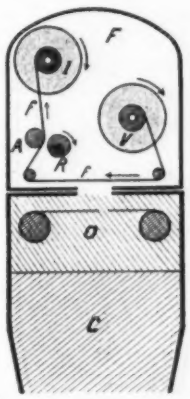

Fig. 7. Diagram of removable film holder of chronophotographic apparatus

C. Dark chamber. *O.* Shutter. *F.* Film. *I.* Roll of exposed film. *V.* Roll of unexposed film. *R.* Cam-bearing shaft of communicating gear. *A.* Friction roller.

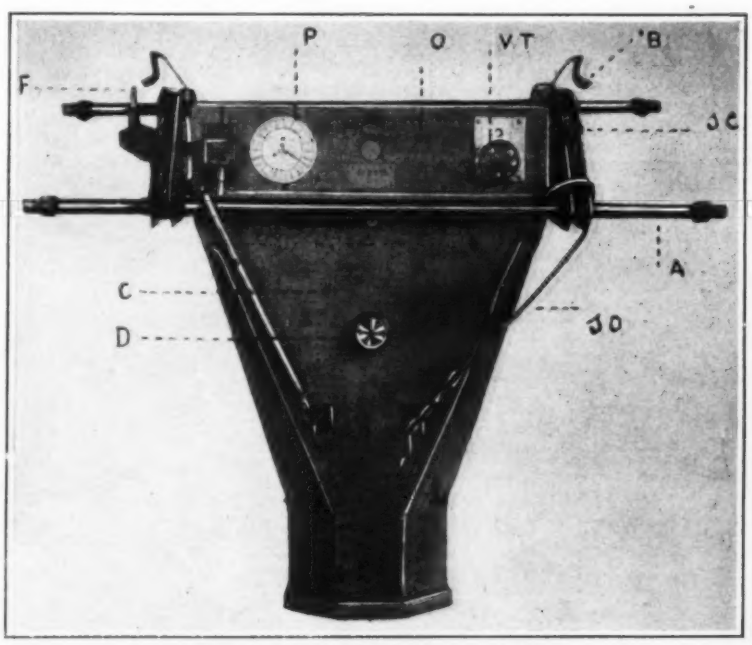

Fig. 6. Chronophotographic apparatus

C. Dark chamber. *O.* Shutter. *D.* Diaphragm. *F.* Current connection. *P.* Register of photographs taken. *T.* Shutter spring tension. *B.* Strap for attaching film holder. *A.* Supporting tubes. *SO—SC* "Sandows" for absorbing shocks and vibrations.

The 0.50 *Apparatus* (Figs. 2 and 3): This is constructed in the same manner as the 0.25 apparatus, having analogous devices to regulate the diaphragm and put the yellow screen in position. Unlike the 0.25 apparatus it contains two distinct devices, one to properly regulate the width of the slit, 2.5, 5, 10, 20 mm. respectively, the other to act upon the tension nut of the release spring with six rates of speed. The combination between the widths of the slits and the tension of the spring permits the obtaining of twenty-four different shutter speeds, varying from 1/85 to 1/850 of a second. This apparatus also has a sight, a double leaved curtain, etc. Complete, with a plate holder containing six plates, it weighs 9.1 kilograms.

The new apparatus of this type is provided with an electric heating device, consisting of a flat rectangular coil containing a resistance, placed in the dark chamber and supplied by the electric current furnished by the generator of the avion. Three degrees of heat can be obtained, the first for temperatures ranging from 0°C. to 15° C., the second for those between 15 and 30 and the third for temperatures below 30° C. The object of heating the apparatus is to increase the sensitiveness of the plates and to avoid the phenomena of condensation. This aparatus is fastened to the fuselage of the avion by means

of shock absorber fastened to a rigid frame bolted upon the longerons.

The 1.20 *Apparatus* (Fig. 4): This apparatus, whose total height is about 1.60 metres, is made of sheet steel. The large lens made by the Goerz firm permits the obtaining of views at a distance of 4,000 metres on a scale of about 1/1333. The shutter devices are identical in almost every detail with those of the 0.25 and 0.50 apparatus, so that the observer has 24 rates of speed at his disposal. The diaphragm is regulated by hand, and directly, as are also the placing and the removing of the yellow screen. This giant apparatus also makes use of 13 x 18 plates. At a distance of 4,000 metres the field of the photograph is about 400 m. x 600 m. on a scale of 1/3333; this apparatus is not employed, naturally, except to photograph points of very special interest, such as heavy batteries, trenches before an attack, etc.

Being very cumbrous it projects beyond the under surface of the fuselage of the avion by about 40 to 50 centimetres, and it is attached by means of frames separated by lock springs, the inside frame being fastened to the apparatus and the outside frame to the avion. Because of the very small field photographed upon each plate it is evident that the observer must have at his command very precise sighting apparatus.

Chronophotography (Figs. 6, 7): The chronophotographic apparatus constructed by the "Projections Maschinenbau Gesellschaft," and installed upon an avion, comprises the following parts:

1. An electric current generator coupled to the motor;
2. A connection box;
3. A mechanical control;
4. The composite chronophotographic apparatus itself consisting of
   (a) A dark chamber;
   (b) A synchronous shuttering device;
   (c) A removable film holder (Fig. 7).

The J. D. Flieger generator is of the type ordinarily employed upon army avions, and has already been described in No. 2328 of *La Nature;* it furnishes a continuous current of 51 watts and 4 amperes, and an alternating current of 270 watts and 3 amperes with a frequency of 600.

The mechanical control consists of a small rheostat, an electric motor with a voltage of 45 which operates the release of the chronophotographic apparatus, a speed controller (permitting the operator to obtain six different speeds, to regulate the interval between exposures), and a volt-meter. These four pieces of apparatus are attached to a board and bolted to the inside of the right side of the fuselage in the observer's seat. The chrono apparatus has a focus of 0.50 m., and is provided with the Zeiss lens mounted on all of the 0.50 apparatus. The dark chamber is in the form of the inverted frustum of a pyramid; it contains the lens whose diaphragm is controlled by a large milled heat button placed on the outside (Fig. 6). This chamber, like all the rest of the apparatus, in fact, is made of reinforced wood covered with cloth. The shutter is of the curtain type and has an alternating movement; the width of the slit is 9 mm. and is constant. A milled head button on the outside permits the regulation of the tension of the shutter spring; there are six possible speeds, the corresponding numbers being shown on a small indicater. A scale graduated from 0 to 400 shows the number of views made by the apparatus.

The film holder is removable, and is attached to the shutter box by two cleat straps. The unrolling of the film is performed by a cog wheel made in one piece with the shutter, and operated by continuous movement. A communicating shaft carrying rubber cams synchronises the movement of the film with the exposures. The working face of the cam is 6 cm., and corresponds to the advance of the film between two exposures (Fig. 7). The film is 16 metres long and 24 centimetres wide, making it possible to obtain 270 views 6 x 24 cm. in dimensions, representing, at a distance of forty-five hundred metres, a strip of territory 145 kilometres in length and 2,100 metres in width. The avion easily carries three magazines, thus permitting the photographing of a strip of territory about 450 km. in length by 2.1 km. in width.

The great superiority of a chronophotographic apparatus over the ordinary or merely automatic apparatus is the possibility of obtaining a large number of views which are perfectly joined one to the other, and this quite independently of the skill of the observer.

This kind of aerial photograph cannot be obtained unless the interval of exposure bears a direct relation to the altitude of the avion and to its speed with respect to the ground. In fact, the field covered by photographs increases with the altitude of the exposure, and the 0.50 m. apparatus which photographs upon a 13 x 18 plate a rectangle 1,000 x 1,400 m. in size, if the exposure is made at 1,000 m., will cover a field of 4,000 x 5,600 m. if the exposure is made at 4,000 m. Furthermore, it will be readily understood that the greater the speed of the avion, the shorter the interval between the exposures must be.

When the observer who is employing a German chronophotographic apparatus wishes to obtain views joined together, he makes use of a table which indicates automatically which of the six shutter speeds he must adopt. The altitude of the avion above the earth is shown by his map and the altimeter of the avion. The speed with respect to the ground is obtained by measuring the time which it takes a given point on the ground to pass through a given angle (see article on Goerz sighting device, *La Nature*, No. 2281). The German avion carrying the chronophotographic apparatus described above possesses the same sort of very simple sighting device, consisting of an index placed on the upper longeron of the fuselage and two marked points on the lower longeron.

The six speeds give intervals of exposure of 17, 14, 11, 8, 6, and 5 seconds. If a 24 x 6 cm. view, taken at a distance of 4,500 metres with a 0.50 m. apparatus, permits the covering of a surface of 2,160 x 540 m., and if the avion is going at a speed of 150 km. per hour, the observer concludes that he must make use of an interval of thirteen seconds, or of speed No. 2, which equals fourteen seconds. If the avion had an altitude of 4,500 m. and is driven by favorable winds so as to cover 200 km. per hour, then the interval of exposure should be 9.8 seconds, or speed No. 3. In spite of its apparent complexity this apparatus is very simple of manipulation and permits the obtaining of maximum results with but little regard to the professional skill of the observer.

The chronophotographic apparatus is suspended by a cardan joint in the fuselage. It has rubber shock and vibration absorbers. It represents a great degree of progress in aerial photography.

Military aviation has become the most scientific weapon possessed by the army; it involves a knowledge of aerodynamics, of the resistance of materials, of explosion motors, of armament, of pyrotechnics, of photography, of electricity, of ballistics, etc.

The German technical achievements have been very considerable. From time to time during the course of hostilities the preponderance in the mastery of the air has changed hands, but at present it appears to belong to us, a circumstance which only incites our enemies to redoubled efforts to wrest it from us. Powerful civil organizations have added their efforts to those of the military in the effort to counterbalance our industrial achievements in this line. It is necessary to work incessantly in order to keep up with the constant improvements in aviation, and if we desire to establish a precedence in this line we must work with frenzied zeal.

Possibly we do not possess all that is required in the way of technical equipment in order to maintain a close survey of the utilization of avions and their accessories at the front, or for studying on the spot hostile avions as soon as they have been brought down; we ought to profit from the experience of our enemies as they have eagerly profited from our own.

Vitamines

It has been discovered during the last 20 years that animals as various as pigeons, fowls, rats, pigs, and man if fed exclusively on polished rice develop the disease known as beri-beri, characterised by serious changes in the peripheral nerves, and that a water, or 90% alcohol, extract of the rice-polishings contains a substance of which very minute quantities prevent or cure the disease.

By careful and laborious experiments with rice and other diets it has been shown that this substance is widely spread in the common foodstuffs and that its presence is essential for life. Attempts to isolate it in a pure state in sufficient quantity for chemical investigation have not hitherto been completely successful, but enough has been ascertained to make certain that it is neither a protein, fat, nor carbohydrate, nor indeed any of the known constituents of plants or animals. It is free from phosphorus, insoluble in absolute alcohol, ether, benzene, acetone, or oils, soluble in water or 90% alcohol, and is absorbed by fullers' earth or animal charcoal. It survives a good deal of cooking at 100° C. but is slowly destroyed at 120°. It is resistant to 5% sulphuric acid. Funk has proposed for it the name "the anti-beri-beri vitamine" and this term "vitamine," although open to many objections, has been widely adopted for substances of this type. The name "sitacoid," meaning a medicine-like substance associated with food, is suggested by the writer as accurately descriptive and not implying a knowledge of their chemical characters which we do not possess.

Most foodstuffs contain adequate amounts of the anti-beri-beri substance but, it is important to note, white flour, polished rice, and arrowroot, and probably also "corn-flour," and much of what is sold as sago, tapioca, and semolina, contain none. Ordinary white bread doubtless contains a little derived from its yeast, but certainly not enough for health unless supplemented by other foodstuffs. Wheat-bran contains a little, wheat-embryo contains a good deal.

It has also been discovered, thanks mainly to the pioneer researches of Hopkins, Stepp, Osborne and Mendel, and McCollum and his collaborators, that rats and mice require not only the anti-beri-beri substance in their diet but at least one other vitamine or sitacoid, and in its absence get sore eyes (Xerophthalmia) and are unable to grow. It will be convenient to refer to this as the anti-sore eyes substance (McCollum's Fat-soluble A).

As found in animal substances it is slightly soluble in water but much more so in oils, ether, and hot alcohol. It is very resistant to ordinary cooking operations, but is slowly destroyed by prolonged exposure to daylight. It has not been identified with any of the chemically known constituents of plants or animals. It is either completely free from phosphorus and nitrogen or, alternatively, it is active in incredibly minute amounts. As found in the higher plants it is insoluble in ether, oil, or hot alcohol. The relations between the plant and the animal anti-sore eyes substances have not yet been ascertained. Proved to be indispensable for mice and rats, and especially for the growth of the young, there are strong reasons also for suspecting it to be equally indispensable for man. It is present in quantity in yolk of egg, cod liver oil, all animal fats investigated (with the remarkable exception of lard), milk, cheese, butter, margarine made from animal fats, green leaves, soya beans, millet, and flax seed. It is absent from lard and all vegetable oils (almond, maize, cottonseed, sunflower seed, linseed, and soya bean oils) and margarines made from them. It is present, although apparently in small amount only, in the (entire) seed of wheat, oats, maize, hemp, rye, and cotton seed.

There are strong reasons for believing that lack of yet a third vitamine or sitacoid is mainly responsible for the disease known as scurvy. This anti-scorbutic substance is remarkable in that although surviving ordinary cooking operations it usually fails to survive slow drying or long "preservation" of the food in which it is contained. It is present in all fresh vegetables, fruit, or meat. It is rarely or never present in dried vegetables. It is absent or inadequate in amount in dried seeds, but it is present in seeds, *e. g.*, barley, peas, which have just been allowed to germinate (Furst, Weill and Mouriquand, Miss Chick).

McCollum's observation that guinea-pigs on a diet of oats do not get scurvy if given laxatives is explicable on the assumption that the anti-scorbutic substance is essential for the normal functioning of the intestine. —*An abstract of a paper by Prof. W. Ramsden before the Liverpool Section of the Society of Chemical Industry.*

Rock Paintings By Bushmen

In the *South African Journal of Science* (Vol. XIII, No. 11, July, 1917), the Rev. Noel Roberts describes a series of Bushman rock paintings discovered at the Zoutpansberg range, in the northern Transvaal, during the construction of the railway to Messina. The ochre used is believed to be derived from a deposit in the neighborhood of the caves, and natives assert that the white paint was obtained from the milky kernel of the Stamvruchte (*Chrysophyllum magaliesmontanum*). Much controversy has arisen regarding the meaning and purpose of the paintings. Some believe that they represent historical incidents, or depict occurrences in hunting. Others trace a connection with the art of northern Africa. But Stow's conclusion that they are purely historical still holds the field. At the same time, as Sir James Frazer has advocated, there may be a magical object, and Mr. Roberts advances some arguments in support of this view. The excavation of the detritus of the caves containing the paintings should bring to light some objects which would help to fix the date and intention of these representations. Meanwhile, the article provides a series of photographs of considerable interest.

Safety of the Alternating Current Crane

The alternating current crane has one inherent safety feature not found in the crane with direct current motors, in that the motor is built with a pre-determined fixed torque, and a heavier load than this maximum torque will handle cannot be lifted, whereas, with the series wound direct current motor, there is no limit to the load it will attempt to lift.

The Interconnection of Economic Botany*

And Chemical Industry

By Edward Wheeler, A.C.G.I., A.I.C.

By economic botany is understood the study of those plants, cultivated or wild, which are or may become industrially important. The work of an economic botanist is firstly to investigate the characteristics of plants of ascertained or prospective value with the factors of yield and distribution; secondly, to determine how far the conditions of soil, manuring, and climate influence the yield and quality of the raw material obtained; and thirdly, to endeavor to improve the plant by seed selection or breeding experiments so as to obtain a strain best suited to different localities and ranges of climate, or most immune to diseases.

The aim of economic botany has been recently very tersely summarised by Rendle, who stated that "improvement from an economic point of view implies co-operation of the botanist and plant breeder. The student of experimental genetics, by directing his work to plants of economic value, is able, by means of agriculture and horticulture, to produce forms of greater economic value."[1]

A brief consideration of the problems met with in the manufacture of the principal products prepared by the different chemical industries from the raw materials furnished by the economic botanist will indicate how far economic botany has assisted chemical industry, and in what directions further work is desirable.

1. VEGETABLE DYESTUFFS.

One of the chief obstacles to the successful cultivation of the indigo plant, namely, its liability to the disease known as "wilt," brought about by the constantly wet condition of the soil, has been overcome by discovering the most suitable planting areas and seasons[2], and by breeding a strain of the plant immune to the disease[3]. Again, the yield of indican has been found to be dependent on the conditions favoring the maximum absorption of nitrogen from the air by the root nodules of the plant[4].

The recent work of Howard and Davis in India in studying the fermentation changes taking place in the vats, whereby the indican is converted into indigo, has demonstrated the importance of controlling these changes for the production of a higher yield of dye and a more uniform product[5].

There are many other less important vegetable dyestuffs which by improved methods of cultivation, of breeding and selection of the plants, or of extraction of the coloring matter, might be successfully exploited, as in so many cases the crudest methods of production were still in use when coal tar dyes replaced the natural products.

2. CELLULOSE PRODUCTS.

Cellulose for industrial purposes is obtained from (*a*) the pecto-celluloses such as cotton, ramine, flax, and hemp, (*b*) the ligno-celluloses such as jute and the woods, (c) cereal straws and grasses[6]. The problems met with in the cultivation of the plants and isolation of cellulose may be briefly alluded to[7].

Cotton.—For the successful cultivation of the cotton plant (*Gossypium*) attention has to be paid to the climate and soil, as slight variations in these factors always give rise to variations in the cotton crops from season to season as regards yield of waste on spinning and general quality of the fibre. Recent work in Egypt has aimed at obtaining a pure strain of cotton plant which will yield cotton of greater regularity in length and tensile strength[8].

Flax.—In the case of flax (*Linum usitatissimum*) study has been devoted to the cultivation necessary to obtain good yields of both fibre and seed,[9] the latter furnishing linseed oil. Research into the isolation of the fibre from the stems by retting—a fermentation process—has led to the use of pure bacterial cultures in order to obtain fibre of good quality and uniformity.[10]

The grasses.—The grasses include the straws, bamboo, and esparto. Interest in the use of straw cellulose[11] has recently revived owing to the increased production of cereals in this country, while the utilisation of bamboo cellulose has been carefully studied by Pearson and Raitt in India.[12]

The woods.—The study of the best conditions of growth in relation to climate and soil, rate of growth, pathology of trees and allied investigations carried out by the Forest Departments will prove of increasing value to the cellulose industries.[13]

Paper.—Constant investigations are being carried out by various workers and by the Imperial Institute as to the suitability of various vegetable fibres for papermaking. In time special crops may be cultivated solely for the production of papermaking materials.[14]

Cellulose nitrates.—The cellulose nitrates are generally manufactured from waste cotton obtained from the textile factories. For nitration purposes uniformity of cotton is most important. It has been claimed that cotton produced in a cold, wet season does not nitrate so readily as cotton grown under more favorable conditions.[15] Consequently improvements tending to give cotton of greater uniformity will also affect favorably the uniformity of the waste cotton.

Both cotton and wood cellulose have been used as raw materials for cellulose nitrate for artificial silk manufacture, though the "silk" made from the former was found to be superior to that made from the latter.[16]

Cellulose xanthate.—Cellulose xanthate (known in solution as viscose) has been most successfully utilised for the manufacture of artificial silk, wood cellulose being the raw material employed.[17] Variations obtained in tenacity and dyeing properties of artificial silk are sometimes ascribed to the original wood cellulose used. A study of the best time of cutting the wood, the best type of tree, and its conditions of growth in relation to the wood cellulose produced from it would be of value in relation to papermaking and artificial silk manufacture.

3. POTASH AND IODINE.

Our knowledge as to the most profitable kinds of waste wood and plants to exploit as sources of potash is very meagre, and there is much need for a systematic survey of the potash content of the ashes from such waste material. Thus it is only recently that the use of bracken and hedge clippings[18] and of banana skins and stalks[19] has been advocated for potash production.

Extended workings of seaweed for potash and iodine have been commenced recently in British Columbia and the United States, but the results so far have not altogether realised expectations.[20] As Hendrick has pointed out, a survey of the seaweed supplies and their rate of renewal, the potash and iodine distribution in different varieties, and the best methods of isolating the products, are all questions to be answered if the industry is to hold its own economically.[21]

4. VEGETABLE OILS, FATS, AND WAXES.

Among products prepared from natural oils, fats, and waxes for soaps are reuired mainly a cheap and plentiful supply of suitable oils, for food products as margarine an almost colorless, odorless, and tasteless oil, for paints and varnishes good drying oils, and for lubricants non-drying or less strongly drying oils. The number of oils satisfying such requirements are many, and the work of the economic botanist is chiefly concerned with the question of increasing the existing sources of supply and studying the physiological processes underlying the nutrition of the plant, and the effect of fungoid and insect diseases in relation to their oil-bearing capacity.[22]

5. VARNISHES AND LACQUERS.

The qualities required of an oil varnish are good color, consistence, drying properties, lustre, durability, and flexibility. These are furnished *par excellence* by the fossil copals; but there seems no reason why, in the future, present day trees should not furnish as good material as the fossil products provided that the economic botanist or forest expert is able to control the methods of cultivation and tapping of the trees, so as to accentuate such qualities in modern resin.[23]

There is a considerable need for physiological and chemical research in order to understand the conditions necessary for the formation and exudation of all resins and the changes undergone by them whereby they become of value as raw materials for varnishes and lacquers.

6. INDIARUBBER.

Hevea brasiliensis[24] has been carefully studied as regards the influence of climate, soils, manuring, straight *versus* forked trunks, efc., on the yield of latex and the best conditions and times for tapping.[25] Generally it has been found that plantation rubber lacks uniformity and shows variations in its appearance, especially noticeable in its behavior on vulcanisation.

As Dunstan pointed out in 1914[26] the origin, nature, and functions in the tree of the latex, which carries the rubber, are not known precisely.

7. VEGETABLE TANNINS.

The scientific exploitation of the tannin-yielding plants has recently increased; thus in India the investigation of the best species of mangrove for the production of mangrove tannin has been undertaken,[27] while in Natal *Acacia mollissima* has been acclimatised and successfully cultivated, good yields of wattle tannin being obtained.

A considerable amount of work has also been done in Sicily,[28] India,[29] and America on the cultivation of sumac, questions as to the kind of planting, methods and seasons of harvesting, and age of plant being correlated with the yield of tannin, work which might be usefully extended to other sources of tannin.

A research into the physiological processes involved in the formation of tannins in the barks of woods would probably yeild useful knowledge as to the best periods and methods of harvesting.

8. (*a*) SUGARS.

The sugar cane (*Saccharum officinarum*) has been cultivated for many years in tropical countries, and much work has been done in determining the best conditions as regards the choice of suitable fertilisers,[30] the selection of the best cane for different soils and climates as in Java[31] and India, [32] yet a recent writer has observed that so little is known as to the essential botanical characters of the various types of sugar cane that experiments on Mendelian lines should be started, as at present no fixity of type can be assured, for even if improved canes are produced they disappear in eight years.[33]

The cultivation of the sugar beet (*Beta vulgaris*) has been most successfully carried out in European countries, where as a result of continuous research work, the sugar content has been raised from 5—6% to 14—18%,[34] while the ash content has been reduced from 3.8% to 2.7%.[34] Experimental agriculture carried out in this country has shown that the beet can be cultivated here as successfully as abroad.[34 35]

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*Abstract from the Jour. Soc. Chem. Ind.

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[5]Chem. Trade J., 1917, 61, 81.

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[21]Hendricks, Rep. Brit. Assoc., 1915, 771; this J., 1916, 372 and 574.

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[23]Livache and McIntosh, "Manufacture of Varnishes," Vol. I. (1904), Vol. II. (1908), Vol. III. (1911).

[24]Potts, "Chemistry of the Rubber Industry" (1912).

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[26]Dunstan, J. Roy. Soc. Arts, 1914, 62, 770.

[27]J. Roy. Soc. Arts, 1915, 63, 442; 1917, 65, 492.

[28]J. Roy. Soc. Arts, 1917, 65, 526.

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[30]Taylor, J. Soc. Chem. Ind., 1914, 33, 211. Geerts, J. Soc. Chem. Ind., 1917, 36, 934.

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8. (*b*) STARCHES.

The chief source of starch for alcohol production is barley, which has been carefully studied with a view to the production of the most suitable kinds for the brewing industry.[36] Other sources of starch for alcohol production are potatoes and maize,[37] the starch content of which has been materially increased by pedigree selection and breeding experiments for the purpose. Reichert has suggested that by methods of breeding it may be possible to produce plants containing starch with the desired properties for textile works more pronounced.[38]

9. FERMENTATION PRODUCTS.

The study of mycology is of great importance to chemical industry in two respects: firstly, in regard to the study of those fungoid diseases which so often affect the yield and quality of many raw materials; secondly, in regard to the study of those decompositions which can be more readily and cheaply brought about than by other agencies.

Besides alcohol, other products are obtained industrially by means of the bacteria or moulds; thus lactic acid is obtained from sugar by means of *Bacillus Delbrückii* and B. *longissimus;* acetic acid from alcohol by means of *Bacterium aceti;* while the moulds *Aspergillacoe* ferment glucose solutions producing citric and oxalic acids.

Doubtless in the future many more products will be made industrially by such agencies; thus, for example, the study of the fermentation of cellulose waste is almost an unexplored field, while the extended knowledge of well-known fermentation processes may be of great benefit to chemical industry, *e. g.*, in the cases of indigo and leather.

10. FOODSTUFFS.

The conditions affecting the regularity of the growth of wheat are dependent on its supply of food, water, warmth, air, light, the absence of poisons and pests, the possession of straw strong enough to support the plant, all of which have an influence in one direction or another on the strength of the flour.[39] The work of Biffen and Howard on Mendelian lines in producing strains of wheat resistant to rust and giving the best results as regards yielding power and quality may be mentioned.[40]

The methods involved in the cultivation and production of tea, coffee, and cocoa all necessitate careful control to enable the best quality to be put on the market.

11. PHARMACEUTICAL PRODUCTS.

Alkaloids.—The amounts of the three principal alkaloids present in *Papaver somniferum*, morphine, narcotine, and codeine, vary according to the variety of plant, methods of cultivation, collection, and preparation of the raw materials adopted, questions which are being studied in India at the present time.[41] In the case of the mydriatic alkaloids, considerable research work has been carried out in determining the influence of such factors as the effect of fertilisers,[42] weather conditions, time of collection,[43] and geographical area,[44] on the content of alkaloid in the plant. Again by suitable selection the content of quinine in cinchona bark has been raised from 3% to 10%.[45]

There is undoubtedly much work to be done in similar directions with other alkaloids, while the study of the mechanism by which the alkaloids are synthesised in the plants may be of great importance to the plant breeder.[46]

Essential oils.—Work has been carried out recently in India[47] and by Baker and Smith in Australia[48] in the direction of surveying trees available as sources of oleo-resin, in studying the most suitable methods of tapping them, and the quality and yields of turpentine obtainable from such resins.

A very careful study of the distribution and quality of camphor obtained from trees of different age has been recently carried out by the U. S. Department of Agriculture[49]—work of great importance if the natural product is to compete successfully with its synthetic rival.

The botanical survey that has been carried out in the eucalypts by Maiden[50] and the chemical work by Baker and Smith[51] might with advantage be extended to many other species.

Generally in the essential oil industry there is much need for correlating the conditions of cultivation and breeding with the quantity and quality of the oil obtained. The metabolic processes underlying the production of the various constituents of the essential oils which in many cases render them so valuable are not understood.[52] Moreover, the right period for separation of the oil will only be found from a study of the physiological changes taking place in the plant.[53]

CONCLUSION.

Much work has been done by the Rothamsted and other experimental agricultural stations, by the different experimental stations connected with the rubber and sugar industries, by the different forest departments such as those in India[52] and the United States,[54] and by the Imperial Institute. Nevertheless, the manufacturer has to deal with raw materials received from a distance and is consequently often out of touch with the cultivation and preliminary preparation of the raw material he receives and is unable to indicate directly to the economic botanist what his special requirements are. Hence the formation of a Raw Material Research Association would seem desirable for studying the problems connected with the cultivation, breeding, and diseases of plants and the furnishing of the supply of raw materials in relation to the requirements of the different chemical manufacturers concerned, a special department or section being formed for each industry or raw material. In this way the interconnection of economic botany and chemical industry would be strengthened to the mutual advantage of science and commerce.

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[51] Baker and Smith, Rep. Brit. Assoc., 1915, 97; Rep. Brit. Assoc., 1916, 201.
[52] Holmes, Rep. Brit. Assoc., 1916, 508.
[53] Perf. and Essent. Oil Rec., May, 1917.
[54] J. Soc. Chem. Ind., 1917, 36, 951.

India Utilizing Native Timber

THE diminution of foreign imports into India has forced the Forest Department to exploit local sources of supply. Home-grown timber is now largely used for industrial purposes. Indian walnut has lately replaced the European variety for rifle-stocks; Chir pine has been found equal to that of Oregon for gun carriages, and Himalayan spruce is little inferior to the famous Sitka variety for the manufacture of aircraft. Materials for paper are being successfully utilized, and tar for the Calcutta jute industry is being distilled in the Punjab. A solution of gum from *Bauhinia retusa* has been successfully used as a binding material for making charcoal briquettes. On the whole, the efforts of the Forest Department to utilize indigenous resources have been well conceived, and promise to be financially successful. —*Nature.*

Treatment of Caustic Soda Burns

As the workmen in the kettle room of the caustic soda works are exposed to painful burns at the syphon line faucet while filling the drums as well as in handling the containers of the molten caustic, some emergency aid should be immediately available for treatments. Mr. M. Firsinger read a paper before the National Safety Convention at New York, in which he recommended a two per cent solution of acetic acid as an acid wash, followed by an oil dressing. Absorbent cotton should not be placed in immediate contact with the wound, but can be used on top of a lint-free pad saturated with vaseline, carron oil or other air excluder. Perhaps aluminium acetate would be a preferable form of neutralizer—especially in cases involving the eyes and lips. Aluminium soap would also be preferable to the lime water emulsions.—*Chem. and Met. Eng.*

Photographic Method for the Examination of Eggs

THE method consists in photographing the eggs directly, while illuminated by an arc or ordinary filament lamp. Before the method can be used practically it will be necessary to obtain more data regarding the increase in the volume of the air chamber in eggs on keeping and the effect of temperature, moisture, pressure, etc. on the same. The method appears to be useful for the examination of eggs preserved in cold-store, but would probably be difficult to apply to eggs pickled in sodium silicate, paraffin wax, limewater, etc.—*Note in Jour. Soc. Chem. Ind. on a paper by G. A. Le Roy in Am. Falsif.*

Fat from Low Forms of Animal Life

DR. P. LINDNER, of Charlottenburg, has taken out a German patent (*Chemiker-Zeitung*), for obtaining fat from low forms of animal life. By populating suitable waste material with these minute forms he obtains material from which fat may be extracted. As examples he mentions decaying mushrooms and non-edible fungi, putrefying meat, gutter refuse, etc., grass and spoilt hay, masses of dead leaves infested with plant-lice, and stale yeast. Dr. Lindner further states that certain materials may be inoculated with the germs of bacteria or microfungi and cultivated. The mass of prepared material is triturated and mixed with water, then heated, and the fat skimmed off; or it may be recovered chemically by treating the triturated mass with a solvent.

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